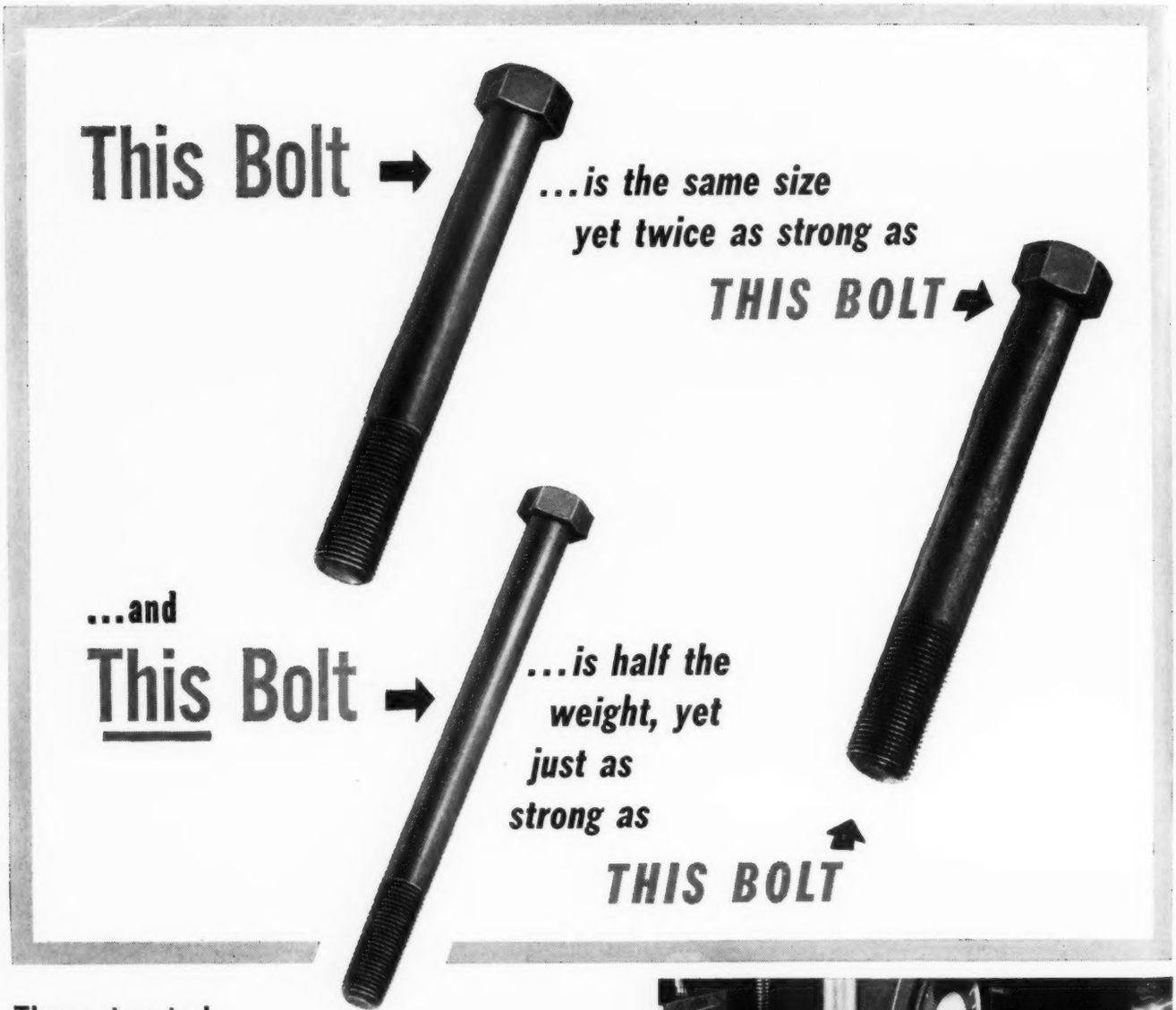
PRODUCT ENGINEERING

SEPTEMBER 1946

IN THIS ISSUE—Specially Designed Motors + Riveted Tension Joints + Spot Welds Alclad + High Temperature Alloys + Strength of Steel Forgings + Limit Switches



These treated NICKEL ALLOY STEEL BOLTS will develop 100% greater unit tensile strength than untreated carbon steel bolts

Whether you aim to gain greater holding power, or save weight and gain space, these Nickel alloy steel bolts will help you.

If bolt holes are already in the part, ¾" heat-treated 3135 or 8635 Nickel alloy steel bolt gives twice the holding power of a ¾" untreated 1020 carbon steel bolt.

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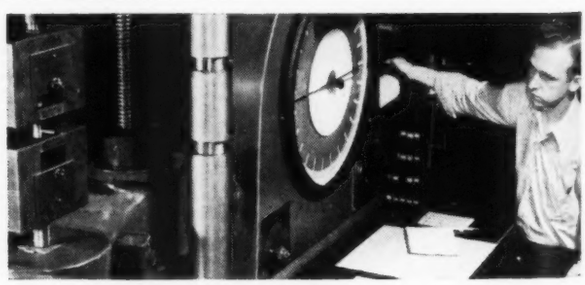

Tensile testing Nickel alloy steel bolts at the plant of Lamson & Sessions Company, Cleveland, Ohio.

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THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N. Y.

This medium-sized tanker broke in half early in January 1943. Sharp straight break indicates that the plates had but little ductility at the low temperature that prevailed at the time of the failure.

Press Association, Inc.

Significance of Impact-Test Data In Design of Engineering Structures

D. F. WINDENBURG
Chief Physicist, David Taylor Model Basin

Examination of Charpy specimens after test reveals that specimens that absorb high values of energy exhibited a considerable amount of ductility, whereas those tested below the transition temperature at which little energy was absorbed showed no signs of ductility. Practicability of requiring impact-test data at low temperatures is discussed.

IN STRUCTURES such as pressure vessels, ships, airplanes, vehicle bodies, and in structural elements such as beams, the allowable working stress is taken as some fraction of the ultimate strength or of the yield strength of the material, as determined by tensile-test coupons. The limiting deflections and the buckling strength are calculated on the basis of the elastic modulus of the material as ascertained from the stress-strain diagram of a tensile-test coupon. However, ship failures and pressure-vessel explosions over the past few years have clearly indicated that physical properties, in addition to yield strength and elastic modulus as determined by tensile-test coupons, contribute to the success or failure of the design.

With reference to the war-time-built welded merchant ships that broke in two, some in dock and some at sea, it was found that all the materials of which they were built met standard specifications for elastic modulus, yield strength, ultimate strength, and elongation. The structures were similar to hundreds of others that were giving satisfactory service and are still in operation. The loading at the time of failure was not abnormal and should have been adequately covered by the factor of safety. Yet the structures failed; and they failed in tension, not in compression.

All of the failures seemed to have had two elements in common: The failures occurred at reduced temperatures and the metal fractured without appreciable elonga-

The opinions expressed in this article are those of the author and are not to be construed as official opinions of the United States Navy Department.

tion. This made it appear that the fractured materials were not sufficiently ductile and did not meet the specifications for ductility. However, tensile-test coupons cut from the fractured plates and tested according to ASTM specifications showed the required ductility.

Results of the investigations immediately posed the questions: Was the lack of ductility exhibited in the fractured plates the result of stress conditions? Or was the lack of ductility a mechanical property not revealed by the tensile test data? Or was it a combination of both?

Causes of Failure

Extensive investigations of the broken structures showed that the fractures apparently were initiated as cracks, which when once started were propagated with such speed as to produce a loud report similar to an explosion. The origins of the cracks, when traced by the herringbone pattern, were usually found to have been in regions of high stress concentration such as the corners of the hatch openings on merchant ships, and frequently in or near welded joints. This indicated that the stress conditions were certainly a contributing factor and pointed the finger of suspicion toward welding, since similar failures had not been experienced on the older riveted structures.

The onus for the failures then seemed to be on the welding or on the material, or both. It is recognized that during the press of war production adequate control of welding sequence was frequently subordinated to increased rate of production. Because faulty welding produces conditions such as porosity, slag inclusions, and undercutting, which in themselves become centers of stress concentration in regions of high stress, inadequate welding control resulting in faulty welding undoubtedly contributed to some of the failures. But it certainly was not the basic cause for all the failures because if the material had been ductile, the concentrated stresses would have been relieved by the yielding of the material. Obviously the evident lack of ductility was the root of the failures.

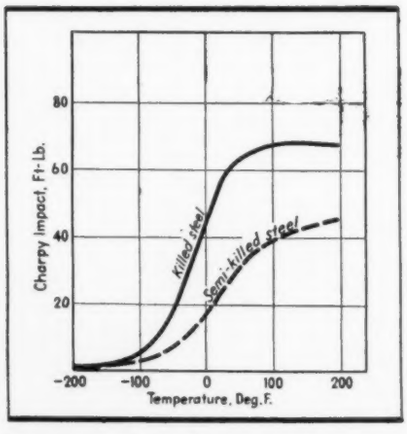


Fig. 1—Typical Charpy-impact curves for semi-killed and fully-killed medium steel. Note the steep slope of the curves in the transition region between high-energy and low-energy values. The temperature at which the energy values begin to decrease rapidly is called the transition temperature.

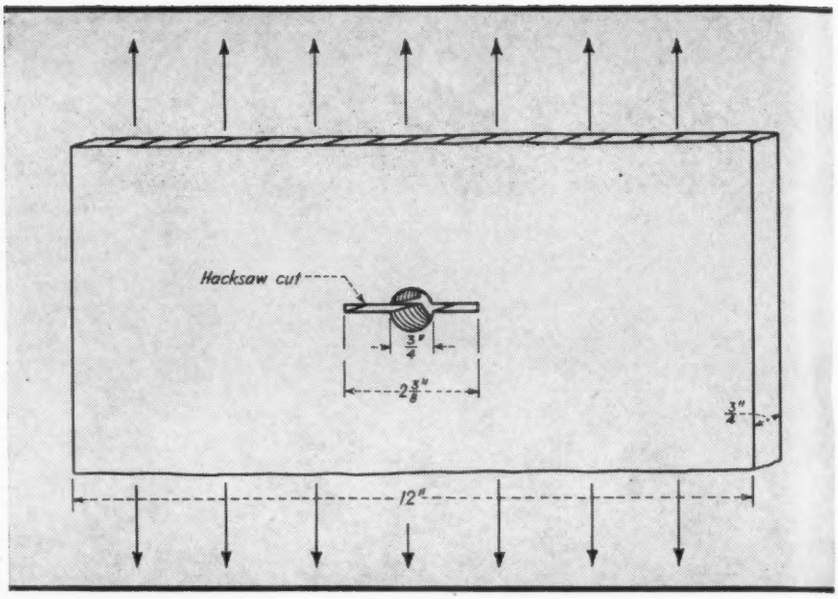


Fig. 2—Form of tensile-test specimens, also the shape of the notch and the size of plate; all specimens were 24 in. long.

Why should a material that is ductile when tested as a standard tensile coupon fracture without appreciable elongation in the completed structure under normal service conditions? Much thought and research work has gone into this problem and although a final answer has not been reached considerable progress has been made. This article is confined to a brief statement of the work on this problem carried on at the David Taylor Model Basin.

Rapid propagation of a crack with small absorption of energy indicates that the material has a high notch sensitivity. Impact tests made with both keyhole-notched and V-notched specimens cut from fractured plates of broken ships showed abnormally low values of energy absorption when the tests were made at the low temperature at which the structures fractured in service. This immediately indicated that the notch sensitivity of the material caused the crack to be propagated with extreme rapidity, once it was initiated.

The magnitude and character of the relationship between Charpy-impact test values and temperature is shown in Fig. 1 by the two typical Charpy-impact curves of energy absorption plotted against temperature. It will be observed that for the higher temperatures the energy absorption is high, whereas for the lower temperatures the energy absorption is low. Moreover, the transition from high to low energy absorption is abrupt. An examination of the Charpy specimens after test reveals that the specimens that absorbed high values of energy exhibited a considerable amount of ductility, whereas those tested below the transition temperature at which little energy was absored showed no signs of ductility. In fact, the transition temperature can be determined about as well from a visual inspection of the broken specimens as from a curve of energy absorption plotted against temperature.

Do the same conditions exist for large structures under static loads? Will a small crack or discontinuity in a steel plate stressed in tension propagate rapidly with little energy absorption at low temperatures, but slowly with high energy absorption at normal temperatuires when the plate is pulled under static load? Is there an abrupt transition temperature from low energy absorption to high energy absorption as shown by Charpy-impact data? If so, can impact tests be used to show at what temperatures a given material will behave in a brittle manner and at what temperatures it can be depended upon to have adequate ductility to prevent the formation and propagation of cracks?

To answer these questions, plate specimens similar to those shown in Fig. 2 were pulled to rupture at different temperatures at the David Taylor Model Basin. It will be observed that these specimens had an artificial notch or crack transverse to the direction of loading. Notches with different degrees of sharpness were used, varying from natural fatigue cracks to drilled holes 2 3/8 in. in diameter. Little difference was observed between the behavior of the plates with natural cracks and those notched with a jeweler's saw. Consequently

most of the tests were conducted on specimens similar to those shown in Fig. 2 with notches made with a jeweler's saw.

In such tests, it is difficult to determine the energy absorption in way of the notch as is done in Charpy tests. However, energy absorbed in any gage length spanning the notch can be readily measured. Moreover, the ductility of the material in way of the notch can be observed visually, and, as has already been pointed out in the case of the Charpy tests, these visual data give a good indication of the transition temperature from low values to high values of energy absorption.

The results of these tests were not as clear-cut as the results of the Charpy tests; there was a much greater scatter of the data. However, they did indicate clearly that at certain temperatures the specimens exhibited high ductility in way of the notch whereas at lower temperatures other specimens of the same material fractured in a brittle manner. Moreover, in the specimens that showed high ductility the cracks propagated slowly, requiring increased load to produce rupture even after the cracks had extended for a considerable distance across the width of the plate. In these specimens, the plastic flow at the end of the cracks decreased the acuity of the notches and apparently delayed the growth of the cracks. This condition is shown clearly in Fig. 3. On the other hand, the plates that fractured in a brittle manner let go with a loud report, the cracks propagating across the plate at a velocity that may approach the velocity of a stress wave in steel. Figs. 3 and 4 show two of the fractured specimens.

Similar tests on plates of other types of steeel, which showed lower transition temperatures by Charpy-impact tests, likewise showed lower transition temperatures from ductile to brittle fractures. This presents convincing evidence that Charpy-impact data can be of real value in screening material that may perform in a brittle manner under tensile loading. If this is true, some specification of safe impact values at the lowest working temperature should be included in the selection of steel that is to be subjected to appreciable tensile loading.

However, if it were required that sufficient impact-test data be obtained to establish curves of energy plotted against temperature, similar to those shown in Fig. 1, it would be time consuming and costly. Also, a well controlled technique would have to be used if the data obtained from the same material by different laboratories are to be consistent.

Test at Low Temperature

Moreover, data obtained at one or two convenient temperatures cannot be safely extrapolated to lower temperatures. The most convenient single low temperature to use in the tests is the temperature of melting ice, but the impact data obtained at that temperature cannot be used to predict the notch sensitivity of the same material at a temperature even only a few degrees lower because of the relatively steep slope of some of the curves in the region of the transition temperature.

If the impact tests are to be conducted at only one temperature the only safe temperature to be used is one below the lowest working temperature of the structure. Such a single temperature for American structures might be chosen as —40 deg. F., although for some designs it might be necessary to use an even lower temperature. Of course for structures that are to be used at room temperatures, the temperature of melting ice would be a satisfactory one at which to conduct the impact tests.

It might seem revolutionary and unnecessarily expensive to require impact data for acceptance of materials to be used under tensile loading. However, it should be pointed out that the requirement of tensile-test data was once considered even more revolutionary and required much more expensive testing equipment. Nevertheless, today the use of tensile-test data as the basis for procurement of steel is accepted as a matter of course. All structural and inspection laboratories are equipped with modern tensile-testing machines and the testing techniques have been so well developed that permanent, reproducible, autographic records can be obtained rapidly and cheaply.

It is believed that similar progress can be made to make it commercially feasible to specify impact figures for acceptance purposes. Once standard specifications have been established the initiative and ingenuity of the engineers called upon to make the tests can be counted upon to devise simple, reproducible, and inexpensive methods of obtaining the required data. Possibly simple static tests might be developed to give the necessary information.

It is therefore recommended that the acceptance specifications for materials to be used under tensile loading, especially at low temperatures, require impact or other suitable tests to insure adequate ductility at the structure's working temperature.

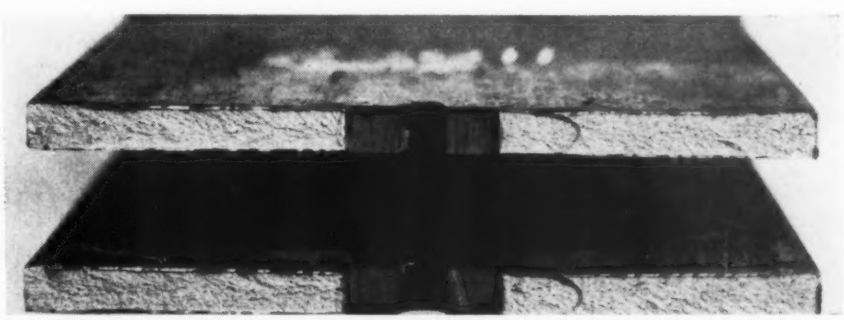


Fig. 4—Tensile specimen that was pulled at 75 deg. F. The two faces of the fracture surface are shown.

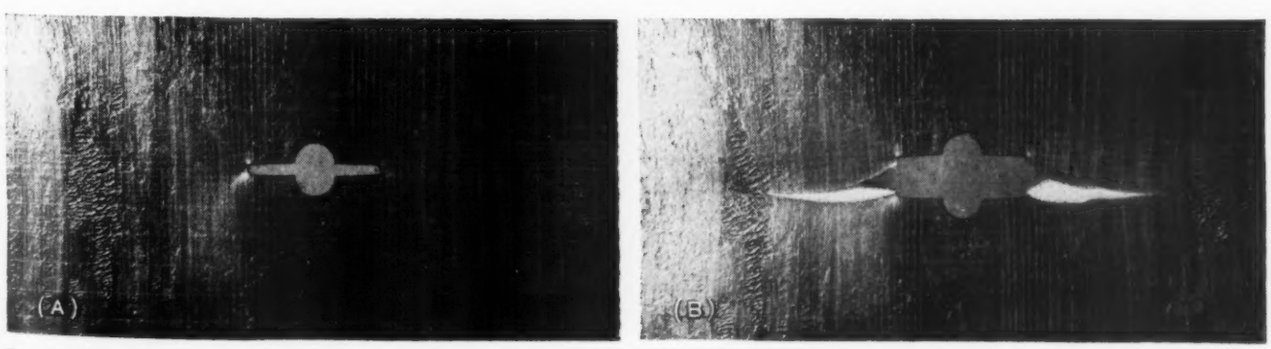
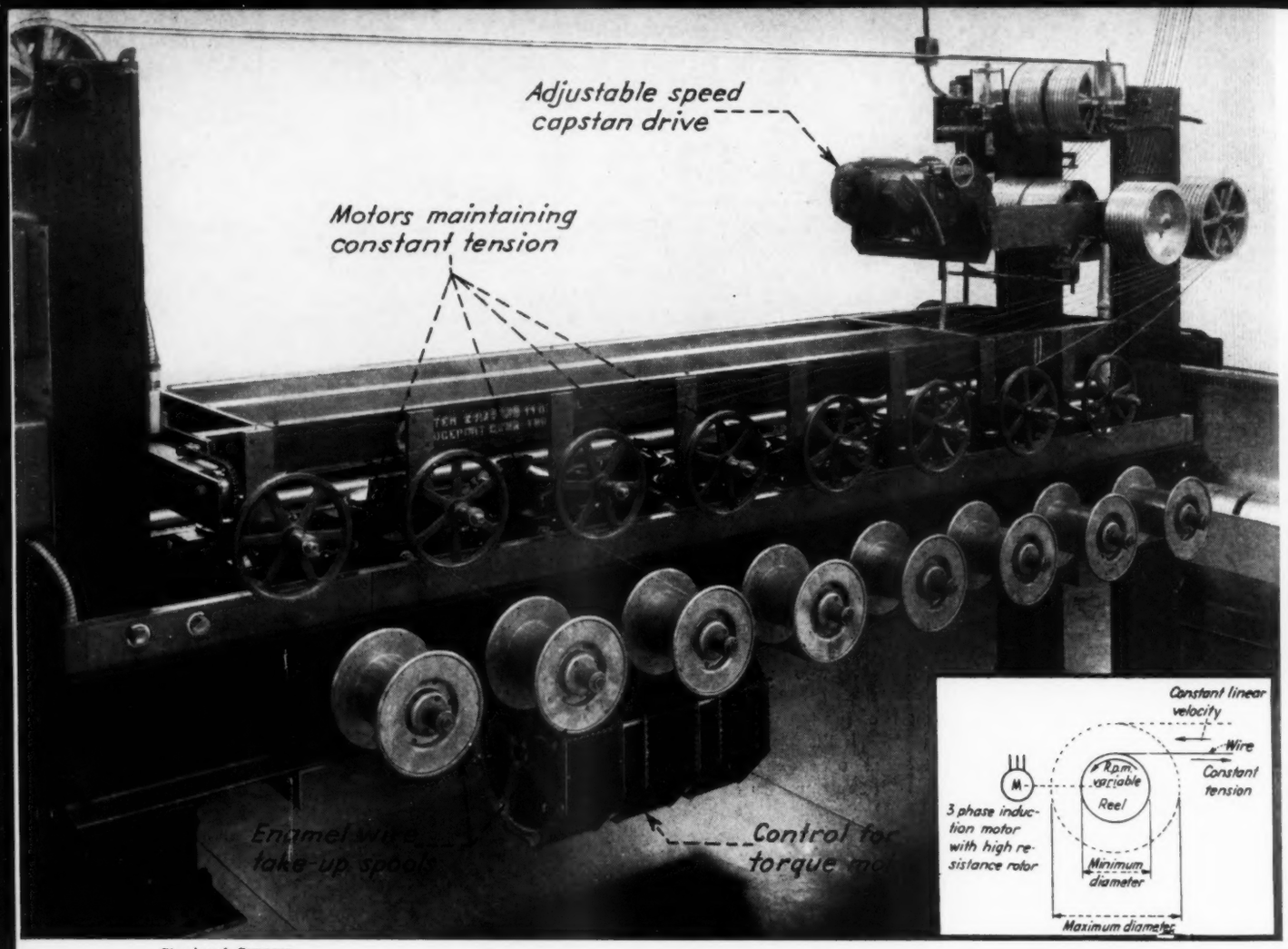


Fig. 3—Tensile specimen tested at 100 deg. F., before and after ductile shear rupture. (A) Intense local strains at ends of notch before rupture. (B) Specimen has begun to rupture. Surface of rupture is on a shear plane about 45 deg. to the direction of loading.



Starring & Company

Fig. 1—Constant tension drive. (A) Typical installation. (B) Schematic showing how wire is coiled with constant tension since the torque of the reel motor is inversely proportional to its speed.

Specially Designed Motors Solve Many Industrial Drive Problems

R. C. ROBINSON
Electrical Engineer, Electric Specialty Company

Resourceful motor design and ingenious modifications of basic types of motors provide unusual operating characteristics for special industrial uses. Tension control, selective positioning, self-regulating control, and speed response control, are among the applications explained and discussed.

THE TENDENCY toward standardization in manufacturing processes has been accompanied over the years by a corresponding tendency toward standardization in motor design. Both tendencies are justified on good economic grounds. It is interesting, therefore, that in spite of this many new and unusual applications are still constantly arising that can be met only by specially designed motors. The great diversity of industrial products and machines seems to preclude any ultimate possibility of pigeon-holing all motor types and applications into any set pattern.

Large motors are almost universally tailor-made to suit a particular application, but the number of practical types of large motors is severely limited. While small motors have been the most highly standardized, at the same time they provide the most fruitful field for design innovations. It is apparent that very small motor types, such as electric clock and electric razor motors, would be completely impractical if

built in large sizes for high power outputs, but in their own size ranges they serve useful functions. Similarly, difficult industrial problems may often be solved by specially designed small integral and fractional horsepower motors that would be impractical in large sizes.

A few concrete examples of special problems that have been solved shows the remarkable versatility of specially designed small motors. To provide a background for the discussion, some of the more common types of motors and their usual fields of application follow.

Basic Motor Types

A.C. Polyphase Induction Motors. These motors are designed with either squirrel cage or wound rotors. The squirrel cage induction motor is the most widely used of any motor in industrial applications. It is essentially a constant speed motor and it is used wherever sturdiness and simplicity are required. The wound rotor induction motor is an adjustable speed machine and is used for such applications as hoists and fans. It is not completely satisfactory as an adjustable speed drive because of its low efficiency and poor speed regulation at low speeds.

A.C. Single Phase Induction Motors. These motors are designed only for small sizes. They use only squirrel cage rotors and are therefore limited to constant speed applications.

A.C. Synchronous Motors. In the medium and large sizes these have d.c. field excitation; in small sizes they are built as "reluctance motors" with no field excitation. Synchronous motors are used wherever absolutely constant speed is desired or, in the case of the d.c. exciter motors, for unity or leading power factor operation.

A.C. Commutator Motors. This general classification includes single phase and polyphase commutator motors and the repulsion motor. The single phase commutator motor is widely used in electric traction in the large sizes and as a universal motor in the very small sizes. The polyphase commutator motor is little used in this country. The repulsion induction motor is a constant speed machine that is used when superior starting characteristics are required; the plain repulsion motor is used for variable speed applications. Both are built only in the small sizes.

D.C. Series Motors. In small sizes these motors are sometimes built as universal motors, that is, to operate on either d.c. or a.c. supply. Because of their rising speed characteristics on no-load they are usually directly connected to a load.

D.C. Shunt and Compound Motors. Adjustable speed operation may be obtained by either field or armature voltage control, thus providing both a flexible and efficient drive.

Constant Tension Drive

Although squirrel cage induction motors are usually applied for constant speed drives, an interesting exception is their use in the coiling of wire where the tension in the wire and its linear velocity must remain constant as the diameter of the reel increases.

As shown in Fig. 1, the linear velocity of the wire is held constant by the equipment that is delivering the wire to the reel. Since linear velocity is proportional to r.p.m. times the diameter and must remain constant, the motor is required to change its speed in r.p.m. in the inverse ratio of the reel diameters. At the same time, it is a basic requirement of the drive that the tension in the wire remain constant. Since torque is proportional to force times diameter and the force must be constant, the developed torque of the motor must change in the direct ratio of the diameters. To meet these requirements it is therefore necessary that the motor develop torque in inverse proportion to its speed. In other words, the motor must operate at constant horsepower.

The curve of a normal induction motor is shown by curve A in Fig. 2, which obviously does not provide the necessary speed-torque relationship. However by using a high resistance motor, in the motor a new speed-torque curve, *B* in Fig. 2, is obtained. Points X and Y are selected on the speed-torque curve so that the speeds are in inverse proportion to the desired maximum and minimum reel diameters and the torques are in direct proportion to these diameters. The portion of the curve between X and Y is the operating range of the motor and since this portion is almost a straight line the tension in the wire will be practically constant over the entire range. The reel is driven at the correct speed by interposing the necessary gear or belt ratio between the motor and the reel.

If the friction torque in the motor and gear is not too great it is possible to wind wire at different tensions by merely changing the applied voltage on the motor. When the voltage is reduced, all torques are reduced as the square of the applied voltage and the new speed torque curve is similar in shape to the original one. Consequently, all of the speed and torgue ratio remains the same as before; and the wire may be wound at the same operating speed and with a reduced but constant tension during the entire operation.

An induction motor operating with the large slips indicated at points X and Y in Fig. 2 will, however, have relatively high losses and it must be liberally designed.

Position-and-Jog Drive

In contrast to a special motor that does a single task, is a special motor that performs two quite separate functions. An

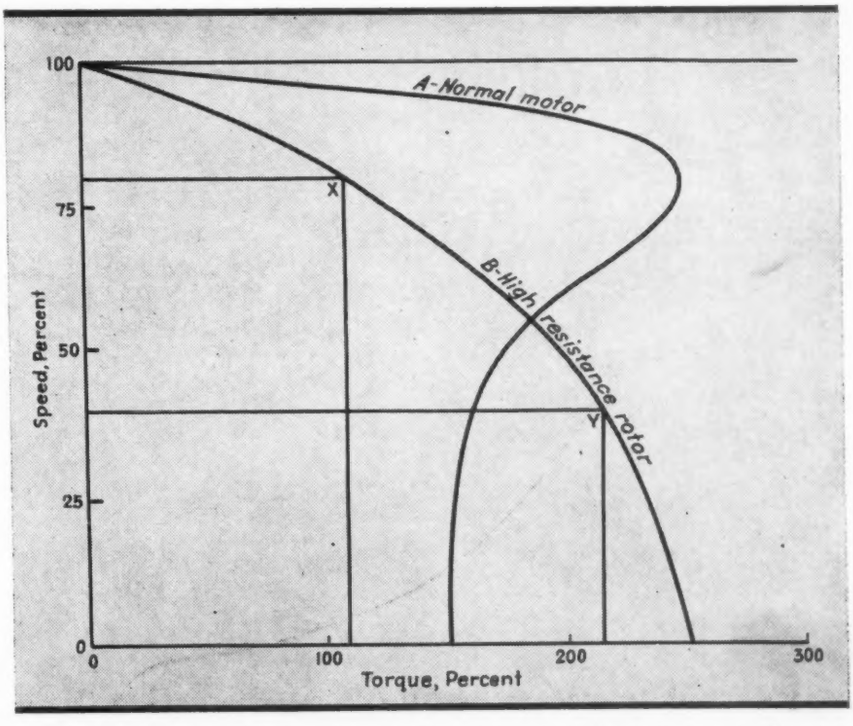


Fig. 2—Increased rotor resistance causes the speed-torque curve of an induction motor to droop sharply thus producing the relatively straight line between X and Y.

example of this type is a "positioning" motor that has one set of windings for normal running and a separate set for positioning the rotor at standstill. A typical application of such a motor is for driving a conveyor that feeds work for a machine tool. The motor carries the work piece up to the machine by using its regular running winding. It then stops and moves the work piece ahead by small increments by means of its positioning winding. In the successive positions, various machining operations are performed on the work.

One set of windings consists of a polyphase induction motor winding on both the stator and rotor, as shown in Fig. 3. The rotor winding is of the wound rotor type, but has its three leads permanently short circuited inside the machine and not brought out to slip rings. Normal running operation is then obtained by applying a.c. voltage to the stator winding, which causes the motor to accelerate to full speed and run at this speed in exactly the same manner as a conventional squirrel cage induction motor.

The other set of windings consists of a polyphase winding on the stator and a d.c. field winding on the rotor. This set of windings has a different number of poles from the main running windings. When a d.c. voltage is applied to the field winding on the rotor and to one phase of the stator winding, the rotor locks into the position in which the two magnetic fields are aligned. By removing the d.c. voltage from this phase and applying it to the next adjacent phase the rotor is moved ahead by an angle corresponding to the angle between the phases, thus giving a jogging movement to the work.

Since the two sets of windings are wound for different numbers of poles the jogging movement is not impeded by any currents and torques induced in the short circuited main rotor winding. This would not be the case if a squirrel cage winding were used in place of the wound rotor type.

Simple Self-Regulating Drive

During the past few years many intricate control problems on large machines and process drives have been solved by the use of Rototrol, Amplidyne, and similar special generators. However, it is sometimes possible to make small motors self regulating without the use of such auxiliaries.

For example, a small motor used to move the electrodes of a carbon arc spotlight together to compensate for the disintegration of the electrodes regulates itself. As shown in Fig. 4, by using an auxiliary field winding on the motor the speed of the motor is varied to maintain constant arc current.

The motor is geared to the electrodes in such a way as to move the electrodes forward at an extremely slow rate, corresponding to the rate of their disintegration. If the motor advances the electrodes too rapidly, the arc current increases, which in turn increases the strength of the auxiliary series field and the speed of the motor is reduced. If the motor advances the electrodes too slowly the opposite action occurs and the speed of the motor is increased. Thus, the arc current governs the motor's speed to maintain the arc at a constant value.

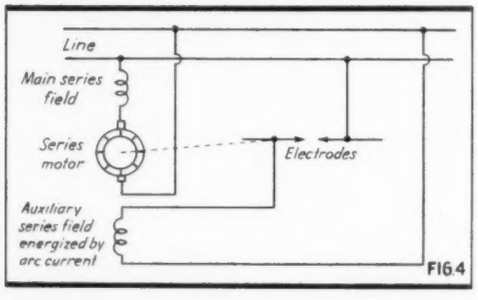
Speed Response Element

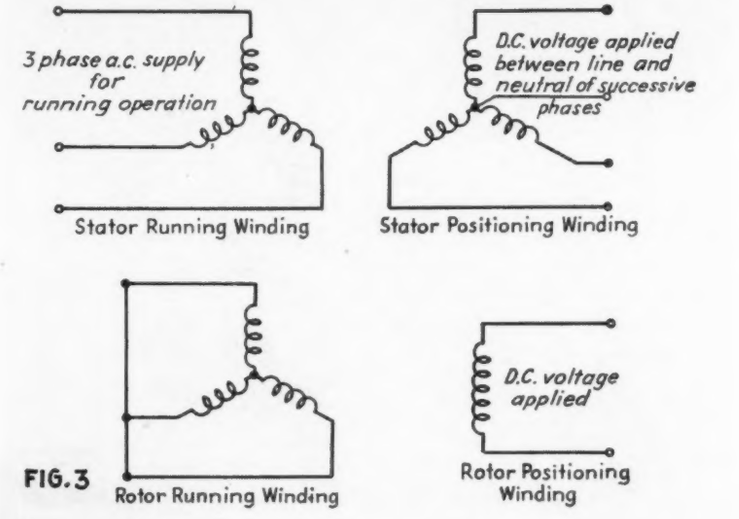
Another interesting application is the use of a special motor for detecting speed changes. During the normal running oper-

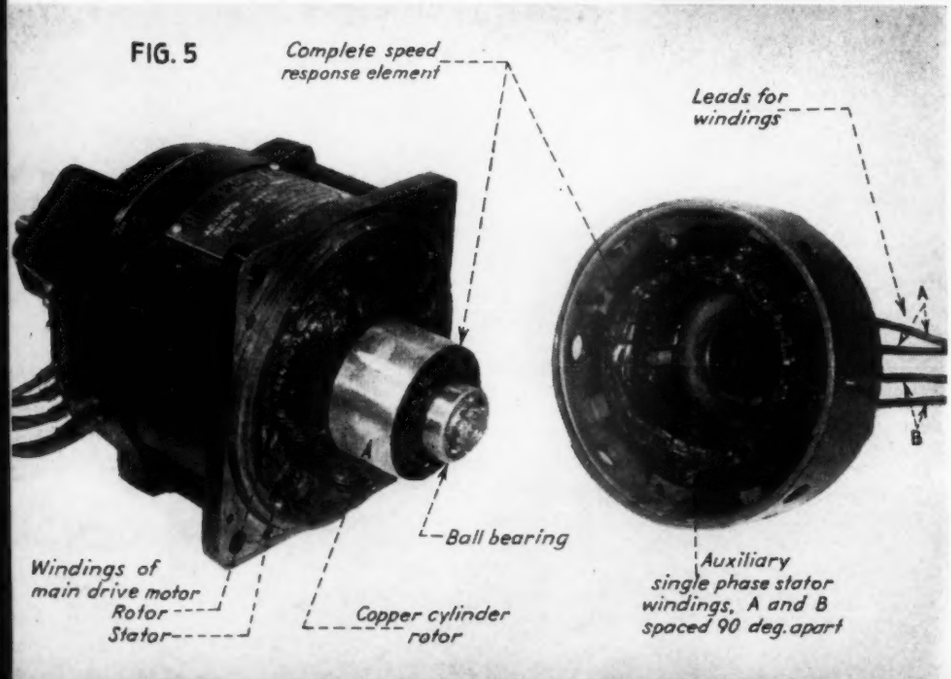
Fig. 3—Motor runs on normal set of windings but, at standstill, the auxiliary winding positions the rotor.

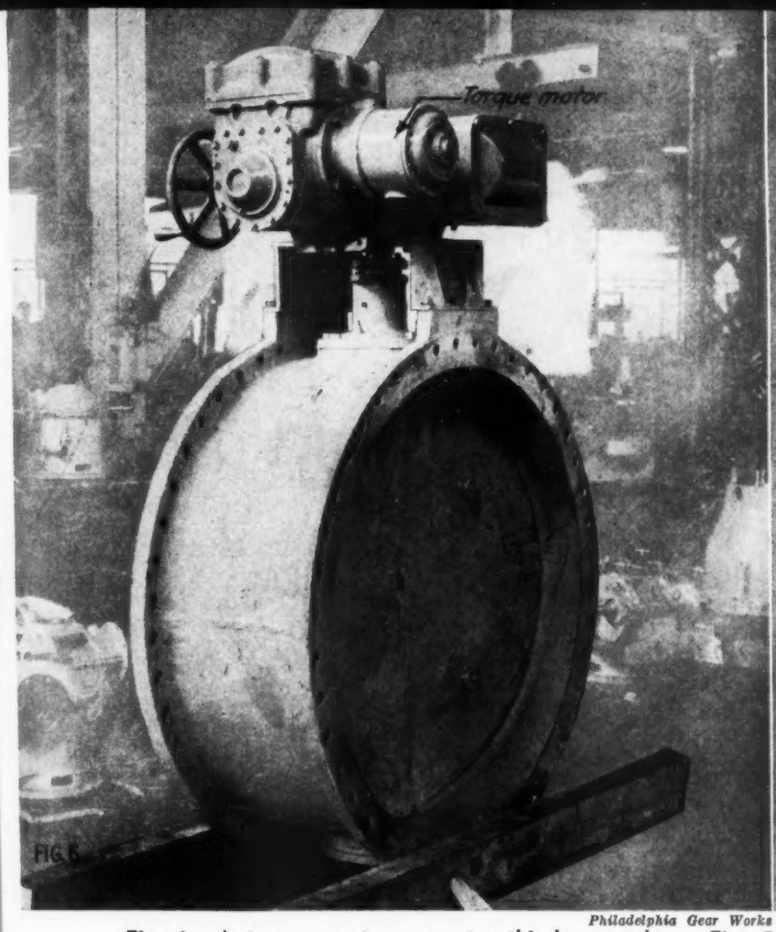
Fig. 4—Changes in arc current increase or decrease the auxiliary field strength to maintain constant rate of electrode feed.

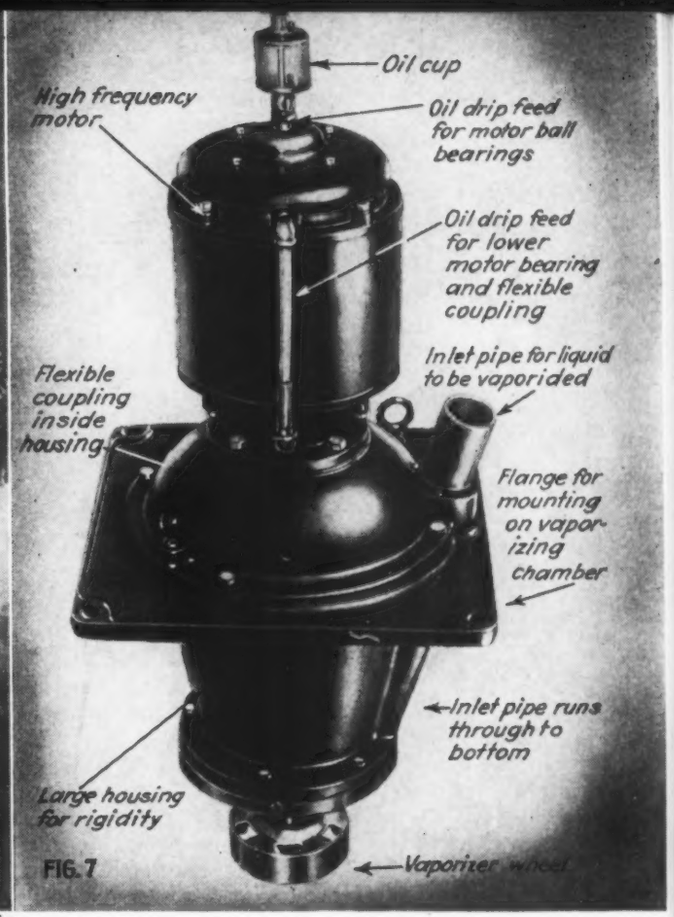
Fig. 5—A special speed-response unit interrelates two single-phase stator windings and a copper rotor to measure speed.




3 phase a.c. supply for running operation
Stator Running Winding
D.C. voltage applied between line and neutral of successive phases
Stator Positioning Winding
FIG.3
Rotor Running Winding
D.C. voltage applied
Rotor Positioning Winding






Oil cup
High frequency motor
Oil drip feed for motor ball bearings
Oil drip feed for lower motor bearing and flexible coupling
Inlet pipe for liquid to be vaporided
Flexible coupling inside housing
Flange for mounting on vaporizing chamber
Inlet pipe runs through to bottom
Large housing for rigidity
Vaporizer wheel
FIG. 7

Philadelphia Gear Works

Fig. 6—A torque motor operates this large valve. Fig. 7—High-frequency 7½ hp., 220-volt, three-phase, 180 cycle, 10,800 r.p.m. induction motor directly connected to centrifugal vaporizer.

ation of a single-phase induction motor two separate magnetic fields are present in the machine. The first is the main single-phase field produced by the stator winding and the other is a single-phase field produced by the rotor that lies along an axis 90 deg. displaced from the main field.

Since this second field varies in magnitude with the speed of the rotor, the machine is connected on the shaft of a main motor and thus detects any speed variations of the main motor.

The stator and rotor of the machine are shown in Fig. 5. The stator has two single phase windings spaced 90 deg. apart, one of which is connected to an a.c. line. The rotor consists of a thin copper cylinder shrunk on a stack of laminations and acts like a squirrel cage rotor. When the main stator winding is connected to the line and the machine is rotating a single phase magnetic field is generated by the rotor along the axis at 90 deg. from the main field. This magnetic field induces a voltage in the auxiliary stator winding. This voltage is at exactly the same frequency as the line voltage, but its magnitude changes in proportion to the rotor speed. Changes in the pilot voltage controls auxiliary equipment to correct the speed automatically.

Some Other Special Motors

A number of other special motor types have been developed in recent years that have found quite widespread usefulness in industry. Many of these give indications of being even more useful to machine designers in the future.

A typical example is the torque motor that is used for such purposes as operating large valves by remote control, as shown in Fig. 6. These motors are specially designed as either d.c. motors or poylphase induction motors. They produce extremely high torque in proportion to their size, but are limited to relatively short time operation. Torque motors in the smaller sizes are usually built totally inclosed, and in certain applications they operate satisfactorily when completely immersed in water.

High speed, high frequency a.c. motors will undoubtedly be more widely used in industrial applications in the future. They are now used on high speed internal grinders where the use of very small grinding wheels require high motor speeds to maintain a reasonable cutting speed. All types of centrifugal blowers and similar machinery often find advantages in using high speed motors since high pressure ratios are obtained with moderate size impellers. For example, the high-speed 10,800 r.p.m. induction motor in Fig. 7 is direct-connected to a centrifugal vaporizer for a chemical process. A drip oil feed lubricates both the ball bearings of the motor and the flexible coupling between the motor and vaporizer.

There are a great many products and processes in industry that require adjustable speed drives, capable of smooth variation over a wide speed range. One of the most satisfactory drives for this type of application is the adjustable voltage, or Ward Leonard system, that uses d.c. machines. The chief disadvantage of this system is its relatively high initial cost since a motor generator set is required in addition to the main d.c. motor drive. For certain applications, a more economical system uses electronic tubes to supply the d.c. motor from an a.c. line. There are a great many variations of this type of drive, but the basic principle of them all is that a number of electronic tubes are used to rectify the a.c. and the magnitude of the resultant d.c. voltage is adjusted by changing the time of firing of the tubes. The timing is varied by phase angle control of the grids of the tubes. Good performance has been obtained and it seems likely that increasing use will be made of electronic drives.

Try Standard Motor First

In choosing a motor for a machine or an industrial drive designers should give first consideration to a standard motor to obtain the advantages of low cost and short delivery. However, if the characteristics of standard motors are not quite suitable for the application a special motor is likely the best solution from an economic and operating viewpoint. The results that can be obtained from special motors are almost unlimited and often an ingenious design modification of a basic motor type will produce the precise operating characteristics that the designer needs for best performance of the product, machine, or industrial process.

Efficiency of Plates In Riveted Tension Joints

F. P. COZZONE
Structural Methods Engineer, Lockheed Aircraft Corporation

Proposed method for estimating the efficiency of plates in riveted lap joints subjected to tension loads. Summary of tests on one hundred specimens covering a wide range of rivet patterns is presented and a comparison of ultimate loads as predicted by the A. R. E. A. method and the proposed method is made with the actual test loads.

SURVEYS SHOW that no one method for determining the net effective section of riveted tension joints is entirely consistent with test data. The surveys also indicate that many conflicting opinions concerning the calculation of net effective section are held by design engineers. The reason for this lack of agreement is undoubtedly attributable to the inherent complexity of the problem.

When considering the problem in its simplest form such as two bars joined in a double riveted lap joint as shown in Fig. 1, where

W_g = gross width, in.
W_n = net width, in.
D = hole dia., in.
P = applied tension load, lb.

it is customary to take the net width W_n through either of the holes as equal to the gross width W_g less the hole diameter D. But since this practice has been found unsatisfactory, it becomes necessary when calculating the net effective width W_e of the bars across the holes, to use a stress concentration factor K such that

$$W_e = K\,(W_g - D) \qquad (1)$$

The value 0.9 is usually assigned as the stress concentration factor.

In a complicated joint like that shown in Fig. 2, Equation (1) is not sufficient, since the adjacence of the rivet holes affects the strength of the plates. If the rows of rivets in the joint are numbered from left to right as shown, the joint may break under a tension load in either of two ways:

1. Straight across the net section of row no 1 or row no. 2.

2. A zigzag break between row No. 1 and row No. 2, or between rows No. 2 and 3.

Where:

W_e = effective net width of plate
D = nominal rivet diameter
$\Sigma\,(D+1/8)$ = sum of all hole diameters in the chain
g = gage, measured normal to the load, of any two successive holes in the chain
N_g = gage spaces in chain
S = pitch, measured parallel to the load, of any two successive holes in the chain

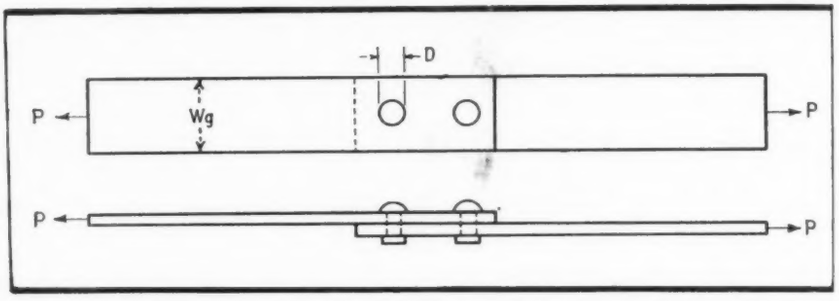


Fig. 1—Simple double riveted lap joint subjected to a tension load.

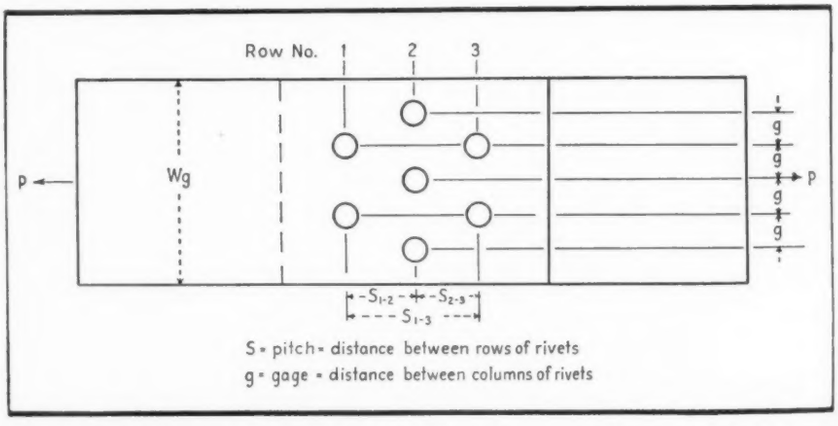


Fig. 2—Triple riveted lap joint in which the adjacence of the rivet holes affects the strength of the plates.

the American Railway Engineering Association offers the following specifications, which is widely used in the structural and ship building industries.

"The net width for any chain of holes extending progressively across the part shall be obtained by deducting from the gross width the sum of the diameters of all the holes (hole diameter assumed equal to rivet diameter plus 1/8 in.) in the chain and adding, for each gage space in the chain, the quantity $S^2/4_g$," or

$$W_e = W_g - \Sigma\,(D + 1/8) + N_g S^2/4g \qquad (2)$$

In the design shown in Fig. 2, the application of the A.R.E.A. specification would necessitate two trials, since there are two chains of holes across which the break might occur. The smallest value would, of course, be the net effective width of the joint. Obviously this method becomes quite unwieldly as the complexity of the joint increases, since each possible chain must be checked to obtain the smallest net

width, or the net effective width of the joint.

Another disadvantage of the A.R.E.A. method is that any omission of holes in the first row of rivets would increase the net effective width and, consequently, the strength of the joint. There are many designs recorded in research reports in which just the opposite is true, that is, the joint is weakened by the omission of holes from the first row.

The following formula is proposed since existing formulas have not demonstrated sufficient consistency as determined by comparison with test results.

Where:

W_e = net effective width of the base plate, in.
W_g = gross width of the base plate, in.
$\eta = W_e/W_g$ = efficiency, percent
D_1 = diameter of the largest hole in the first row, in.
ΣD_1 = sum of the diameter of all holes in the first row, in.
ΣD_p = sum of the projected hole diameters of all holes within a pitch of $5D_1$ of the first row (projected on a plane normal to the load and to the plate), in.
S_{1-2} = pitch between the first and second rows, in.
R_e = total effective reduction in width caused by rivet holes, in.

$$= \Sigma D_p - \frac{S_{1-2}}{5D_1}(\Sigma D_p - \Sigma D_1)$$

$$\eta = \frac{W_e}{W_g} = \left[1 - \left(\frac{R_e}{W_g}\right)^2\right] \left(0.88 - \frac{0.18}{\Sigma D_p/D_1}\right) \quad (3)$$

Values of the expression contained in the parentheses of the right hand member of Equation (3) are given in Table I for values of $\Sigma D_p/D_1$ ranging from 1 to 15.

When only rivet diameters are given, the following practice is recommended:

(1) For aircraft:

Hole diameter = 1.05 × nominal rivet diameter

(2) For civil engineering and shipbuilding:

Hole diameter = 1.15 × nominal rivet diameter

Where there are no rivets in the holes, it is recommended that the net effective width be taken as 0.85 times the net effective width as determined from Equation (3).

To compare the relative ratios of predicted loads, as calculated by Equations (2), and (3), with test load values, a study was made of data published in the following references:

1. "Tension Tests of Large Riveted Joints," by R. E. Davis, G. B. Woodruff and H. E. Davis, *A.S.C.E. Proceedings*, May, 1939. Designs studied 13; seven were made of plate 0.375 in. thick, and gross width W_g was 21 inches.

2. "Discussion on Tension Tests of Large Riveted Joints," by W. M. Wilson, *A.S.C.E. Proceedings*, October, 1939. Designs studied 5; two were made of plate 0.5 in. thick, one of gross width 20 1/4 in. and the other 20 in.; three were made of plate 0.75 in. thick and 22 1/2 in. wide.

3. "Static and Repeated Load Tests of Aluminum Alloy and Steel Riveted Hull Plate Splices," by R. L. Templin and E. C. Hartman, Aluminum Research Laboratories, Technical Paper No. 5. Designs studied 12; plate thicknesses ranged from 0.143 to 0.479 in., gross width ranged from 4.75 to 13.375 inches.

4. "Tension Tests of Heavy Extrusions With Staggered Bolts," by H. L. Adams, Boeing Test No. 20727. Designs studied 5; all made of plate 0.600 in. thick and gross width of 3 inches.

5. "Discussion on Tension Tests of Large Riveted Joints," by E. C. Hartmann and Marshall Holt, *A.S.C.E. Proceedings*, May, 1940. Designs studied 36; 23 specimens were riveted, 13 specimens had no rivets; riveted specimens ranged from 0.041 to 0.500 in. thick, gross width ranged from 1.000 to 14.625 in.; specimens without rivets were made of plate 0.25 in. thick by 5.875 in. gross width.

6. "Bearing and Riveted Joint Tests on X74S-T, Alclad (72S) X74S-7, 24S-T, and Alclad 24S-T Sheet," by E. C. Hartmann and R. L. Moore, Aluminum Research Laboratories Report dated December 30, 1941. Designs studied 31; 15 specimens were single shear joints, 16 specimens were double shear joints. Single shear joints were made of plate ranging from 0.0625 to 0.0710 in. thick, and gross width from 1.125 to 2.000 inches.

The one hundred designs studied included one, two and three row rivet patterns, some with pitches equal in every row, and some with pitches varying in every second and third row. The ultimate tensile strengths of the material in plates ranged from 28,600 to 85,400 lb. per sq. in. Number of projected rivets in the joints ranged from 1 to 15. Effective diameter of rivet holes ranged from 0.131 to 1.150 in. Ultimate test loads ranged from 1,670 to 902,000 pounds.

From this reference data, the predicted load at failure was computed for each design by the A.R.E.A. and the proposed methods and compared with the actual test load failure. Table II gives the comparison of the relative ratios of predicted to actual load values for each method of calculation.

Table I—Factors for Use in Equation (3)

$\Sigma D_p/D_1$	$0.88 - \frac{0.18}{\Sigma D_p/D_1}$
1	0.700
2	0.790
3	0.820
4	0.835
5	0.844
6	0.850
7	0.854
8	0.857
9	0.860
10	0.862
11	0.864
12	0.865
13	0.866
14	0.867
15	0.868

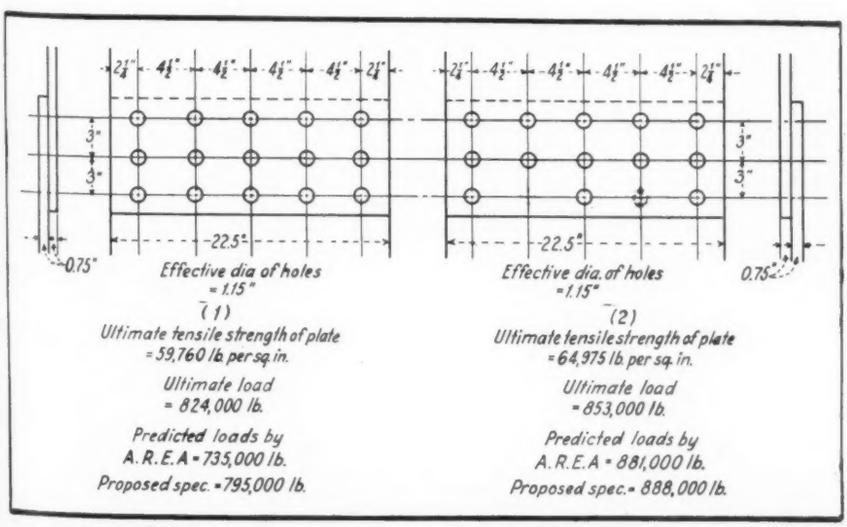


Fig. 3—Comparison of two specimen joints from Reference 2, one having rivets omitted in first row.

The results shown in Table II indicate that, in the majority of designs studied the proposed method is more conservative than the A.R.E.A. specification.

Continuing with the comparison of the A.R.E.A. and the proposed method, Table II indicates that the range or spread of values is better for the proposed method. An inherent weakness of the A.R.E.A. method is that the omission of rivets from

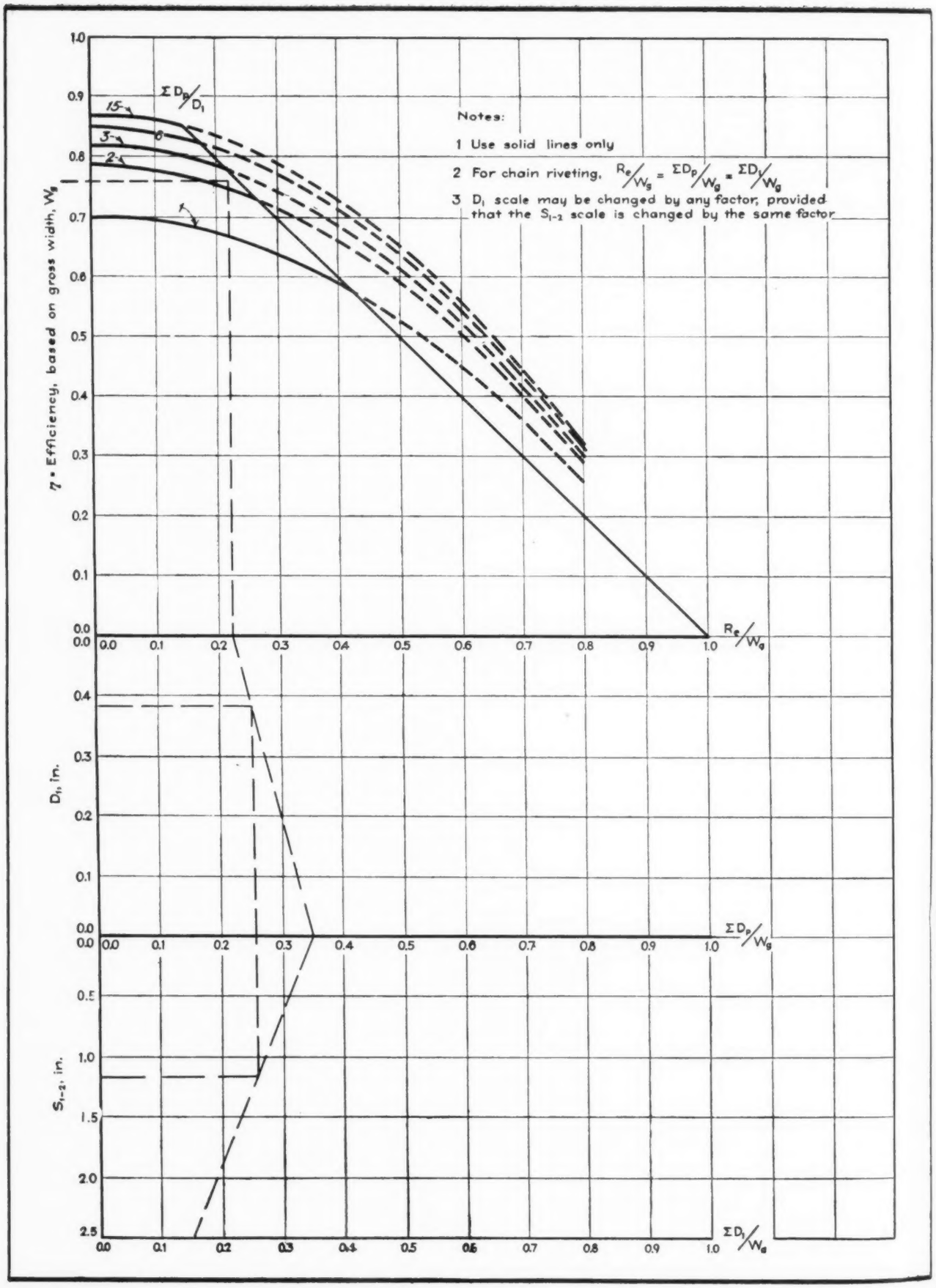


Fig. 4—Efficiency of plates in tension joints.

Table II—Comparison of Predicted to Actual Loads

	Tests and Reference	A.R.E.A. Method	Proposed Method
Minimum ratio	11 Tests from Ref. 1	0.857	0.920
Maximum ratio		1.092	1.025
Average ratio		1.015	0.995
Range		0.235	0.105
Minimum ratio	5 Tests from Ref. 2	0.893	0.895
Maximum ratio		1.110	1.039
Average ratio		1.019	0.975
Range		0.217	0.144
Minimum ratio	12 Tests from Ref. 3	0.875	0.890
Maximum ratio		1.075	1.092
Average ratio		0.957	0.979
Range		0.200	0.202
Minimum ratio	5 Tests from Ref. 4	1.064	0.932
Maximum ratio		1.210	1.010
Average ratio		1.129	0.967
Range		0.146	0.078
Minimum ratio	23 Tests from Ref. 5	0.825	0.885
Maximum ratio		1.182	1.137
Average ratio		0.991	0.969
Range		0.357	0.252
Minimum ratio	13 Tests from Ref. 5 (No Rivets)	0.984	0.870
Maximum ratio		1.190	1.090
Average ratio		1.083	0.999
Range		0.206	0.220
Minimum ratio	31 Tests from Ref. 6	0.915	0.940
Maximum ratio		0.995	1.055
Average ratio		0.954	0.991
Range		0.080	0.115
Minimum ratio	100 Tests from Ref. 1 to 6	0.825	0.870
Maximum ratio		1.210	1.137
Average ratio		1.001	0.983
Range		0.385	0.267

Table III—Comparison of Effective Areas of Two Joints

Method	Net Effective Areas		A_{e2}/A_{e1}
	Specimen 1, A_{e1}	Specimen 2, A_{e2}	
Actual test	13.79	13.31	0.954
A.R.E.A. spec.	12.31	13.58	1.100
Proposed spec.	13.28	13.63	1.025

the first row always gives higher ultimate loads, whereas tests show that this is not always true. Such comparison can be made from two specimens taken from Reference 2. Fig. 3 shows the dimensions and other data for these two specimens.

Both specimens have the same gross width, thickness and bolt size, but differ in material properties. Table III gives a comparison of the net effective areas A_e of the two joints as determined by the actual test, A.R.E.A. specifications and the proposed specifications. The actual test results indicate a reduction of 4.6 percent in A_e resulting from the omission of rivets in the front row; the A.R.E.A. specification indicates an increase of 10 percent; and the proposed specification indicates an increase of only 2.5 percent.

A plot of efficiency η for different values of R_e/W_g is shown in Fig. 4. It is recommended that the solid lines, which have been reduced from the theoretical dash lines determined from Equation (3), be used for evaluating the efficiency. The method of using Fig. 4 to find the efficiency of plates in tension joints, when the rivet sizes and pattern are known can be readily understood by means of an example.

EXAMPLE. A plate has the rivet pattern and dimensions shown in Fig. 5, find the efficiency of the plate.
From the dimensions given:

$$\frac{\Sigma D_1}{W_g} = \frac{0.382}{2.54} = 0.15$$

$$\Sigma D_p = D_1 + 2\,D_2$$
$$= 0.382 + 2 \times 0.254 = 0.890 \text{ in.}$$

$$\frac{\Sigma D_p}{W_g} = \frac{0.890}{2.54} = 0.35$$

$$\frac{\Sigma D_p}{D_g} = \frac{0.890}{0.382} = 2.33$$

On Fig. 4, draw a line connecting point 0.15 on the $\Sigma D_1/W_g$ scale and point 0.35 on the $\Sigma D_p/W_g$ scale. Next, intersect this line with a horizontal line drawn through point 1.34 on the $S_{1\text{-}2}$ scale. From the point of intersection draw a vertical line until it intersects with a horizontal line drawn through point 0.382 on the D_1 scale. Extend a straight line through this point of intersection and point 0.35 on the $\Sigma D_p/W_g$ scale until it intersects R_e/W_g scale. From this point of intersection draw a vertical line to the $\Sigma D_p/D_1$ curve having a value of 2.33. From this point extend a horizontal line to the efficiency scale, this gives a value of 0.76 for the efficiency of the plate.

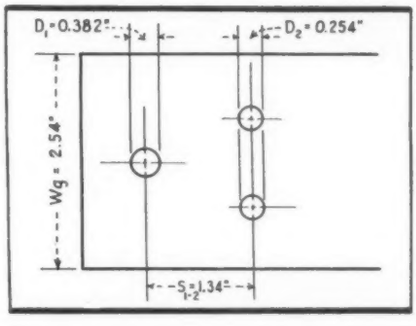


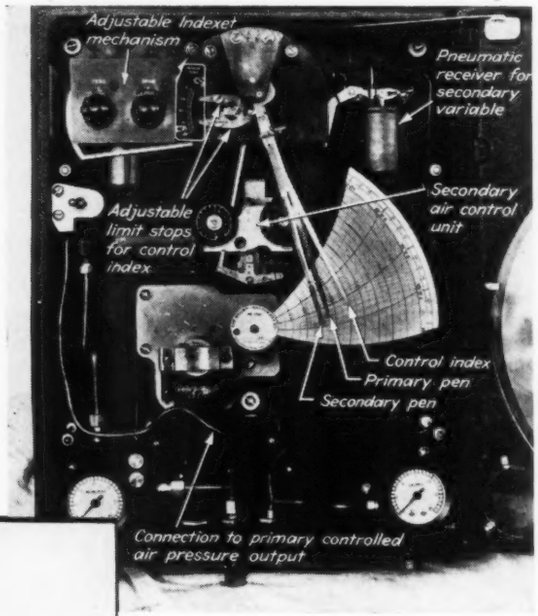
Fig. 5—Hole pattern and dimensions of specimen plate.

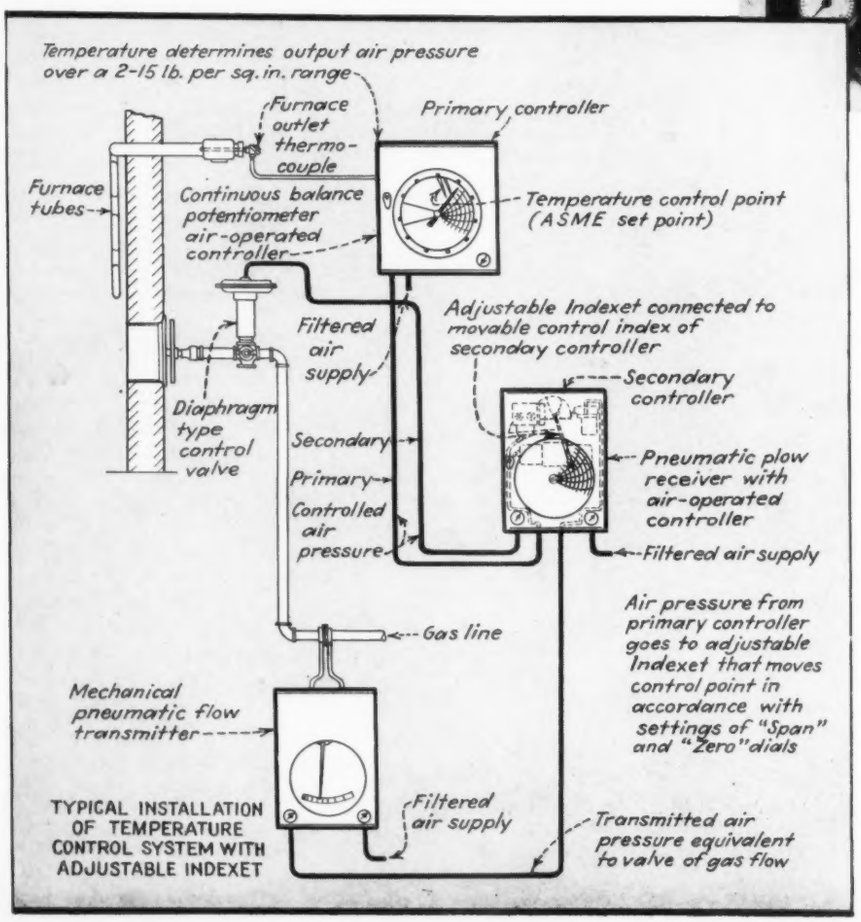
When calculating the plate efficiency, the entire width of the joint should be used instead of a smaller representative width. The use of the latter would give lower values of $\Sigma D_p/D_1$ and therefore efficiencies that are too conservative. If the stress varies across the width of the joint, or if the hole pattern is not constant, then the maximum stress for any representative width should be used with the efficiency as determined by Equation (3).

A review of the data here discussed indicates that additional research is necessary before the effects of the different factors that contribute to the strength of riveted joints are completely understood.

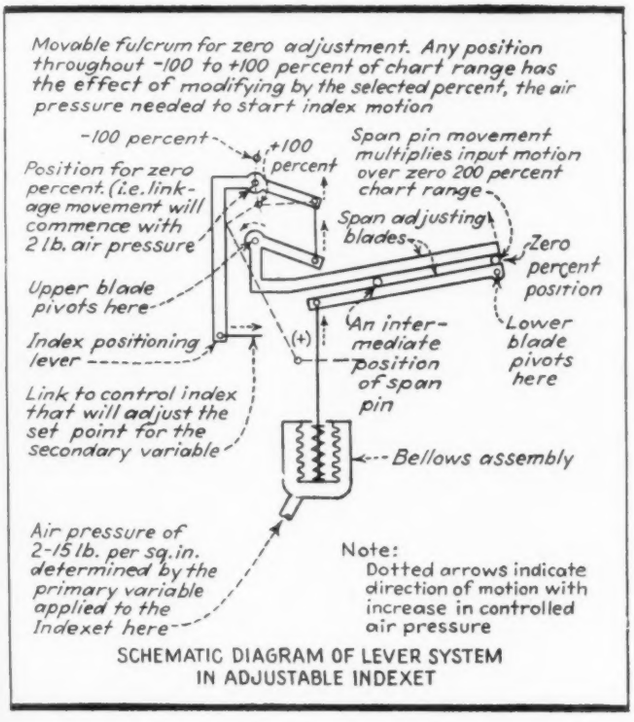
PRODUCT DESIGNS

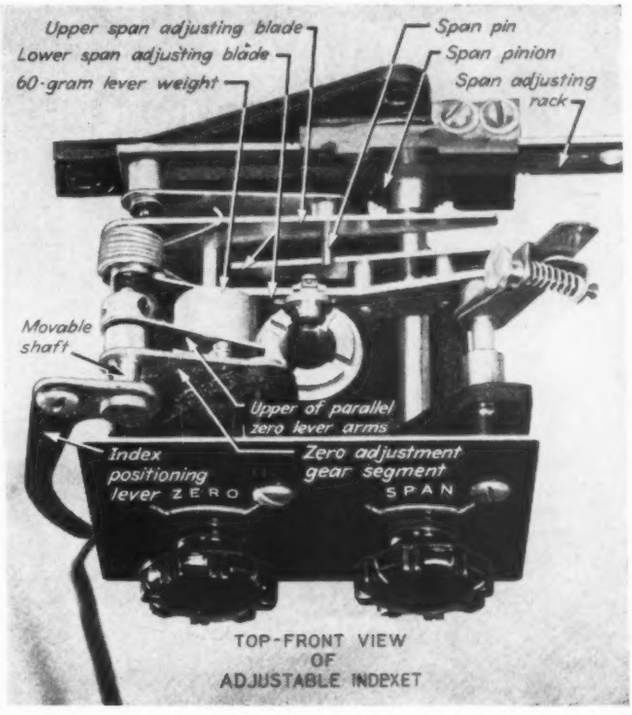
Compound Adjustments Made to Linkage Output With Movable Fulcrums




Temperature determines output air pressure over a 2-15 lb. per sq. in. range
Furnace outlet thermo-couple
Primary controller
Furnace tubes
Continuous balance potentiometer air-operated controller
Temperature control point (ASME set point)
Adjustable Indexet connected to movable control index of seconday controller
Filtered air supply
Secondary controller
Diaphragm type control valve
Secondary
Primary
Controlled air pressure
Pneumatic plow receiver with air-operated controller
Filtered air supply
Gas line
Air pressure from primary controller goes to adjustable Indexet that moves control point in accordance with settings of "Span" and "Zero" dials
Mechanical pneumatic flow transmitter
Filtered air supply
Transmitted air pressure equivalent to valve of gas flow
TYPICAL INSTALLATION OF TEMPERATURE CONTROL SYSTEM WITH ADJUSTABLE INDEXET

IN PROCESS-INDUSTRIES air-operated controllers are often used to regulate the flow of fluids so as to maintain a primary variable at a certain value, or in a certain relationship with a dependent variable. For example, the deviation of a primary variable such as furnace temperature from a preset value is converted into changes in air pressure over a 2 to 15 lb. range. These pressure impulses are used to set an index point on a secondary controller that holds fuel flow at the value prescribed by the index. The amount of index motion for a given deviation, or the deviation required to start index motion, may have to be changed at different stages in the process. These adjustments are effected separately or concurrently to suit the process. The Adjustable Indexet, built by the Brown Instrument Company of Philadelphia, accomplishes such compound adjustments with a bellows actuated by air impulses from the primary controller, and a linkage mechanism that transmits the bellows movement to set the index of the secondary controller.


Movable fulcrum for zero adjustment. Any position throughout -100 to +100 percent of chart range has the effect of modifying by the selected percent, the air pressure needed to start index motion
-100 percent
+100 percent
Position for zero percent. (i.e. linkage movement will commence with 2 lb. air pressure
Span pin movement multiplies input motion over zero 200 percent chart range
Span adjusting blades
Zero percent position
Upper blade pivots here
Index positioning lever
(+)
An intermediate position of span pin
Lower blade pivots here
Link to control index that will adjust the set point for the secondary variable
Bellows assembly
Air pressure of 2-15 lb. per sq. in. determined by the primary variable applied to the Indexet here
Note:
Dotted arrows indicate direction of motion with increase in controlled air pressure
SCHEMATIC DIAGRAM OF LEVER SYSTEM IN ADJUSTABLE INDEXET

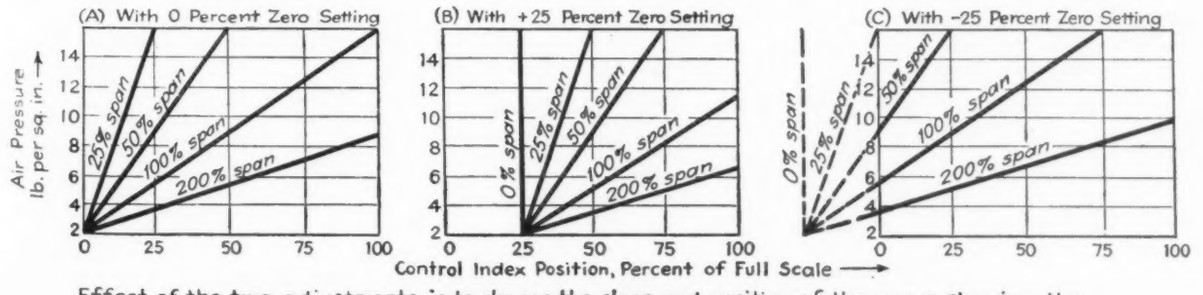


TOP-FRONT VIEW OF ADJUSTABLE INDEXET

Vertical input motion from the bellows rod is converted into rotary motion of the upper span blade. Adjustment of the span pin changes the lever lengths of the two blades measured from their respective fulcrums, hence amount of angular movement for a given input motion. The zero lever input arm is parallel to the span output arm when the zero fulcrum is at zero percent setting, so that in this position index motion will start with 2 lb. per sq. in. air pressure. A shift in the zero fulcrum changes the angular position of the zero input lever, hence the position of the control index, but it does not alter the amount of blade movement in response to a change in air pressure. When the span pin is set at "zero percent span adjustment" there is no motion of the control index regardless of the value of the controlled air pressure. Thus the Indexet multiplies the input by any factor from 0 to 200 percent, and adds to or subtracts from the input any amount between —100 to +100 percent of the chart range. Mechanical limit stops can be set to prescribe maximum and minimum limits of change. The use of small angular movements throughout reduces calibration errors.

Linkage has two movable fulcrums: "Span", to multiply the amount of linkage motion for a given air pressure; and "zero", to prescribe the pressure at which linkage motion will commence. Span adjusting mechanism consists of two blades pivoted at their opposite ends and a movable span pin between them. To multiply the input motion by any factor from 0 to 200 percent, a rack and pinion is used to move the span pin. Zero adjusting mechanism is a simple lever pivoted on a movable shaft. Fulcrum shaft can be moved through a small arc by means of a segmental lever having gear teeth that mesh with a pinion on the shaft of the zero adjusting knob. Backlash in the span and zero adjustments is minimized by the use of spring pressure so that both sides of the pinion driving teeth are in contact with the driven teeth at all times. Remaining backlash is prevented from affecting index motion by having the overbalanced weight of the levers act in one direction throughout the full scale of travel of the index. A weight of 60 grams is added to the lower span adjusting lever to cause the bellows rod to seat in a definite position when air pressure drops to its minimum value.

Relationship Between Air Pressure and Index Position for Representative Span and Zero Settings

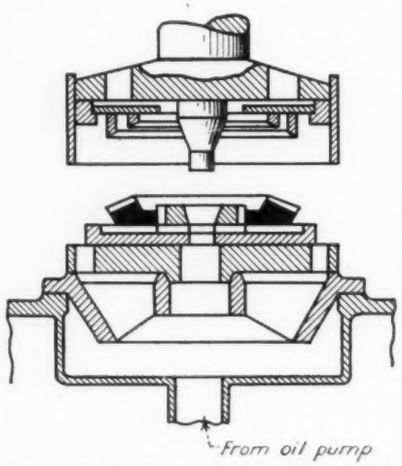

(A) With 0 Percent Zero Setting
(B) With +25 Percent Zero Setting
(C) With -25 Percent Zero Setting
Air Pressure lb. per sq. in.
25% span
50% span
100% span
200% span
0% span
Control Index Position, Percent of Full Scale

Effect of the two adjustments is to change the slope and position of the curve showing the relationship of the primary and secondary variables

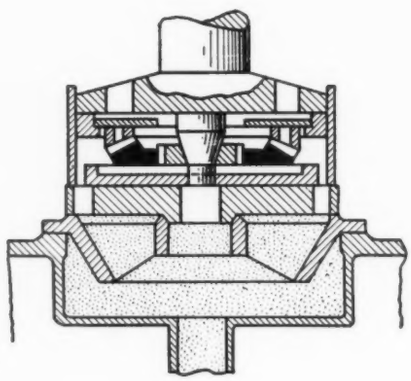
Automatic Press Holds Gears And Prevents Distortion During Quenching

PRESS DESIGNED for holding and quenching heated gears and other parts so that they may be hardened without distortion has been developed by the Gleason Works, Rochester, N. Y. Known as the No. 16 Quenching Press, it is designed for oil-quenching only and is air-operated. Quenching cycle is automatic after part to be hardened is placed in the die and the start push button is operated. Three pre-set timers determine the sequence of the quenching cycle. Capacity is such that parts up to 15 in. outside diameter can be quenched in the machine. Production capacity ranges from 10 to 120 pieces per hr. depending on the size of section and rate of quench.

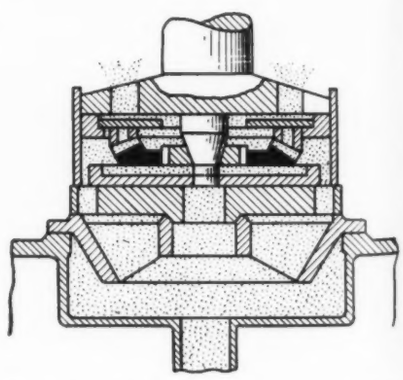
Operating cycle is controlled by limit switches and consists of four steps: 1. Lower die is swung back into quenching position. 2. Upper die descends rapidly until it approaches work when it is slowed down to contact the workpiece and apply full pressure. 3. Quenching oil begins to flow upward around the workpiece and continues according to a predetermined sequence of volumes and time intervals. 4. At the end of a prearranged time the upper die moves vertically and the lower die swings out to the loading position.



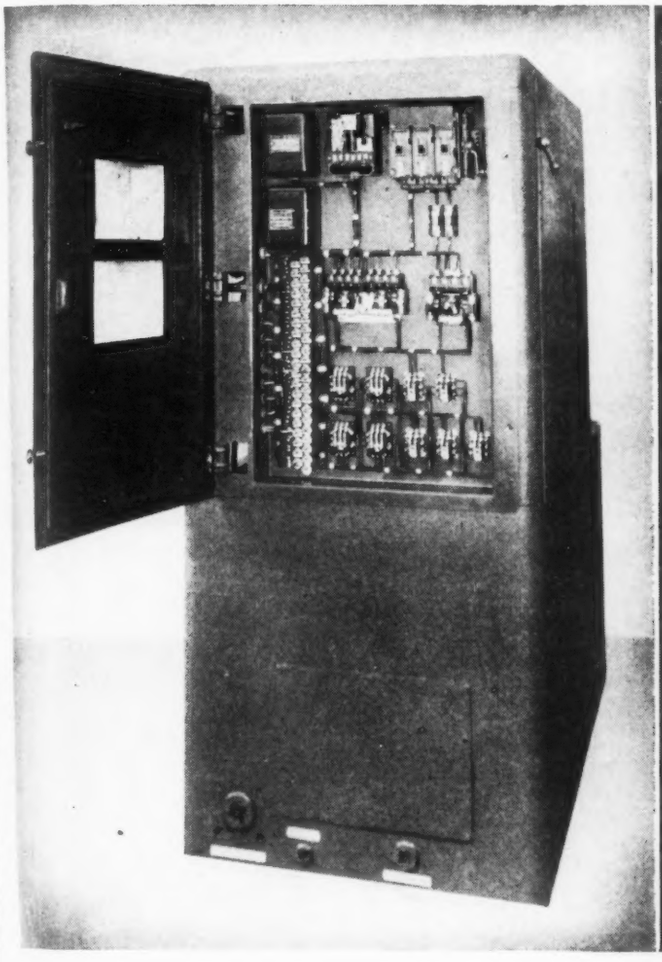
Hot gear on lower die in quenching position

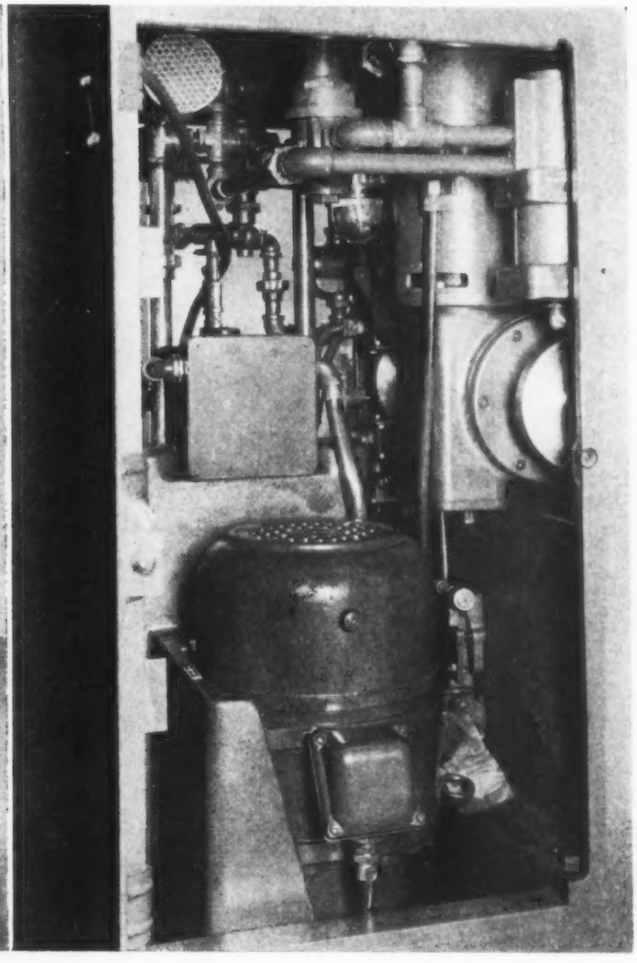


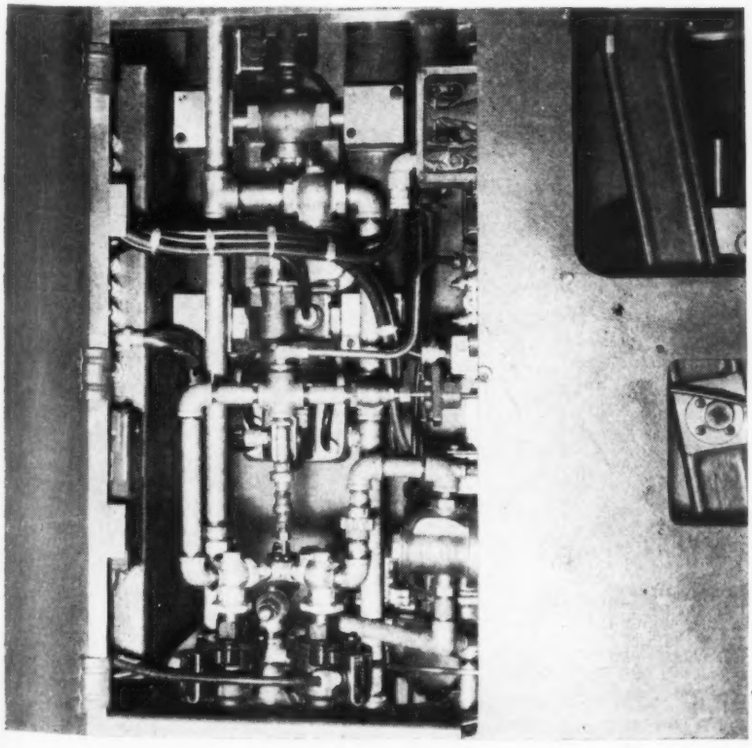
Upper die contacts work. Work aligned while still in plastic state



Timing cycle begins and quenching oil is forced into quenching chamber and around gear. Quantity and time cycle are under positive control during complete quenching cycle







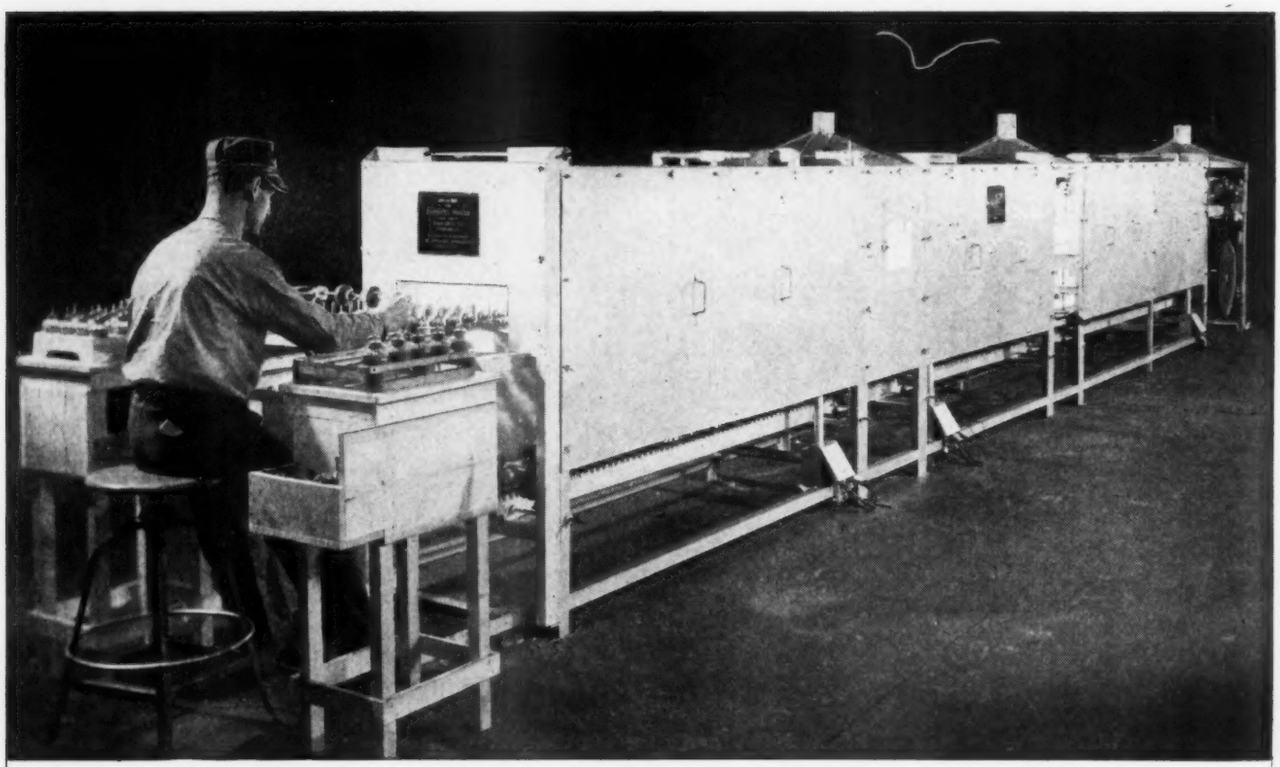
Electrical design is in accordance with the latest Machine Tool Electrical Standards. The control inclosure and wiring are sealed from the rest of the machine with a neoprene seal at the door. Other features include a built-in interlocked disconnect switch, 110 volt fused control circuit, overload and undervoltage protection, and accessibility of all electrical components for inspection and maintenance.

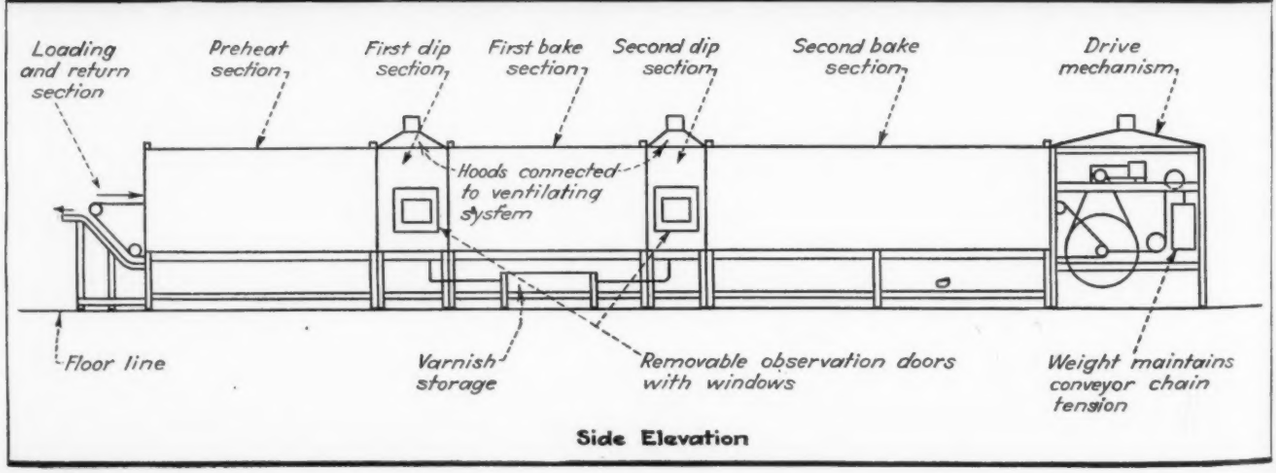
Centrifugal pump is mounted to the rear of the upright and has a capacity of approximately 210 gal. of oil per min. Pump is connected through solenoid operated valves that control the flow of quenching media. These valves are held open by electronic timers that control the duration of each stage of the quenching cycle.

Solenoid operated valves are used to control the air that operates the ram. This allows a rapid approach and slow engagement of the upper die with the work piece. A limit switch operates the solenoid valves so that last 1½ in. of ram travel is slowed down.

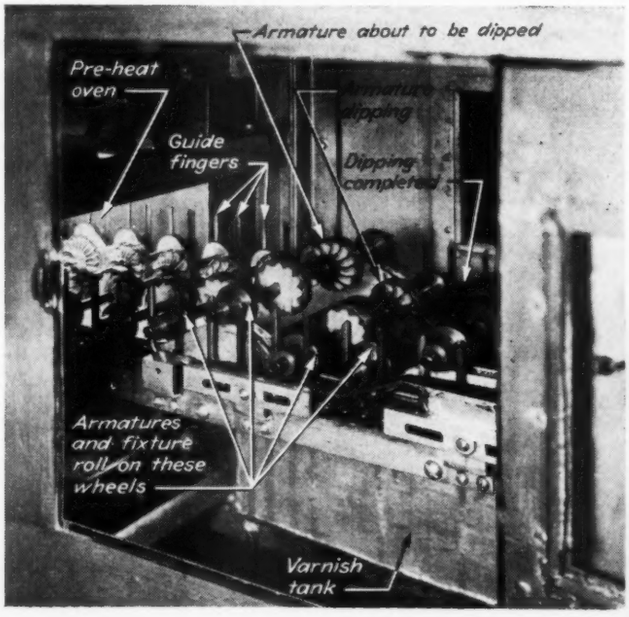
Insulation Varnish Applied By Rolling Armatures Through Tank

INSULATING VARNISH is applied to armatures with the Zanderoll Machine in 10 to 50 percent of the time required by conventional methods. Time savings are made because the usual draining period is shortened and bake time is reduced. Varnish distribution is so uniform that balancing can be done before treating. Reliability and thoroughness of the application have cut down the number of rejects. An example of a machine to accomplish a process, rather than just an operation, this engineering development of the Sterling Varnish Company of Haysville, Pa. is built and installed by the Blaw-Knox Company. The Zanderoll process utilizes a combination of conveyor system, a series of dips, and the application of heat as the pieces travel continuously through an oven. The machine can be built for any required number of dips and bakes, and for armatures over 2,000 lb. weight. Any kind of heat can be used, although infra-red is particularly applicable.



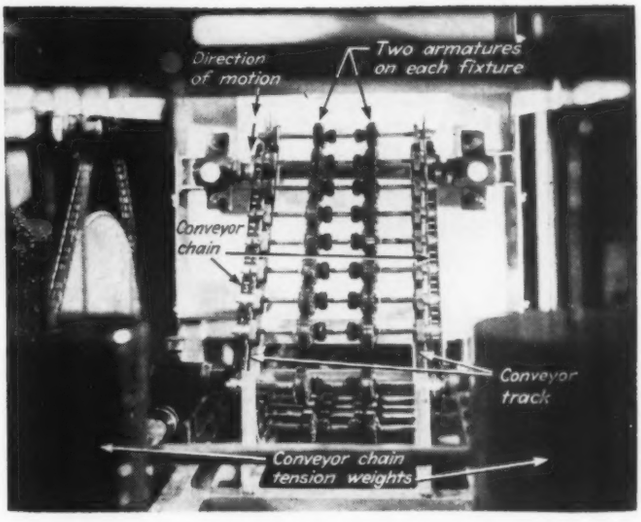


Side Elevation



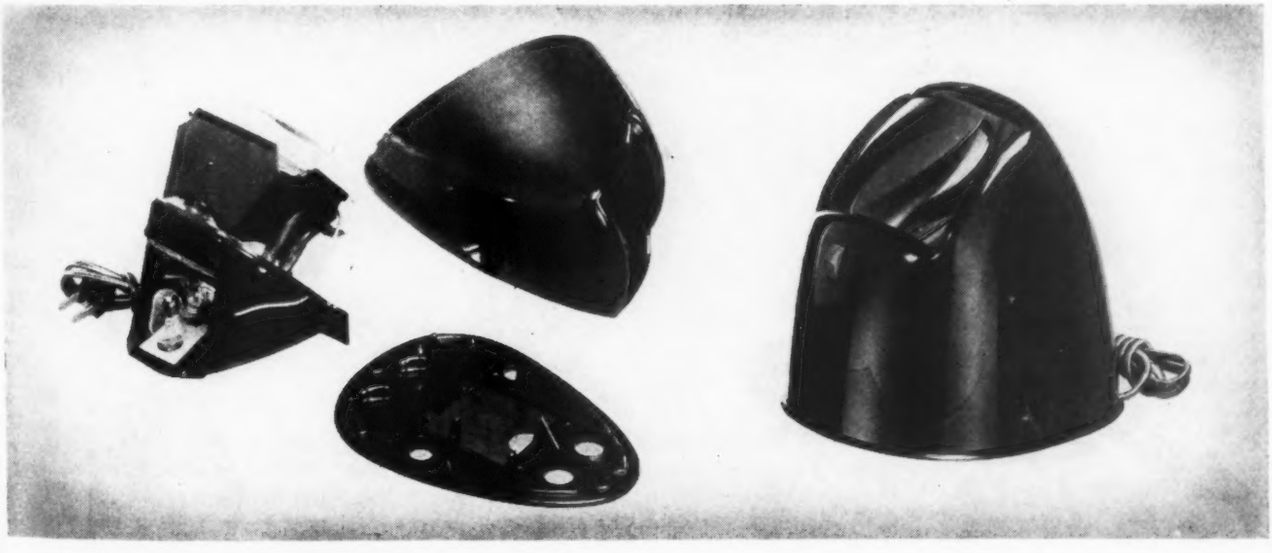
Parts not requiring insulation stay clear of the varnish as the rotors are rolled through the dip tank. Wastage is small since there is no drainage. Small tanks are used so that the varnish is consumed quickly; this reduces the amount of thinning required. Hoods over the dip tanks carry off any fumes that may collect. Removable doors give access to the dipping tank. Windows permit observation.

Attachable extensions having a knurled rim disk at their outer ends are slipped over each end of the armature shaft. The disks roll along the conveyor track, causing the armature to revolve as it goes through the dipping and drying operations, thus assuring uniform application of varnish and thorough drying. Motion along the track and the spacing between units are governed by the fingers of the conveyor chains. These fingers form guide slots for the fixture axles. After final bake the continuous chain and track carries the work back to the loading station. About 200 armatures, 5½-in. dia., are treated in an hour.



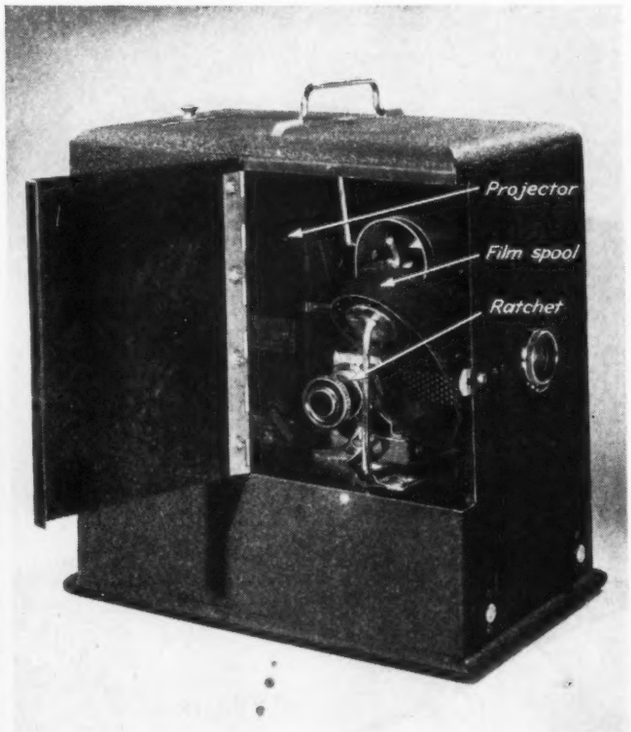
Slide Viewer Made from Phenolic Plastic

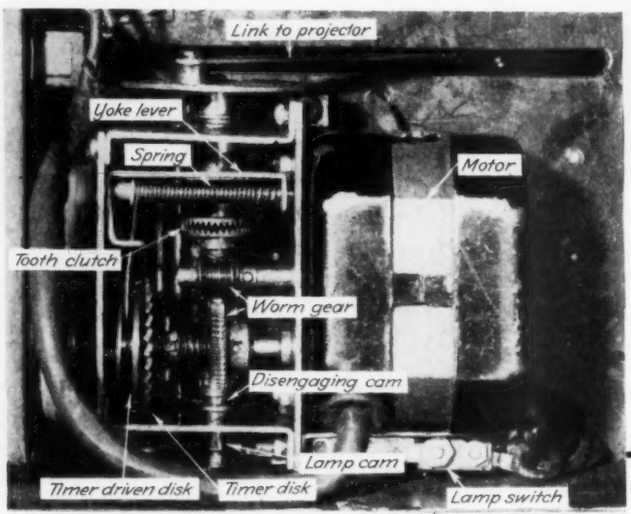
DESIGNED for use in visual selling as well as for dentists, engineers and amateur color photographers, is the new Adel slide viewer. Manufactured by Adel Precision Products Corporation the slide viewer has a well styled appearance. Structural parts are molded from Durez phenolic plastic of its low thermal conductivity, strength and lightweight. Viewing lens is fully corrected and designed for a quick easy change of slides. Housing and internal structural parts are molded by the Reinhold-Geiger Company and the smooth, lusterous finish will not wear off, mark or chip easily and does not require polishing.



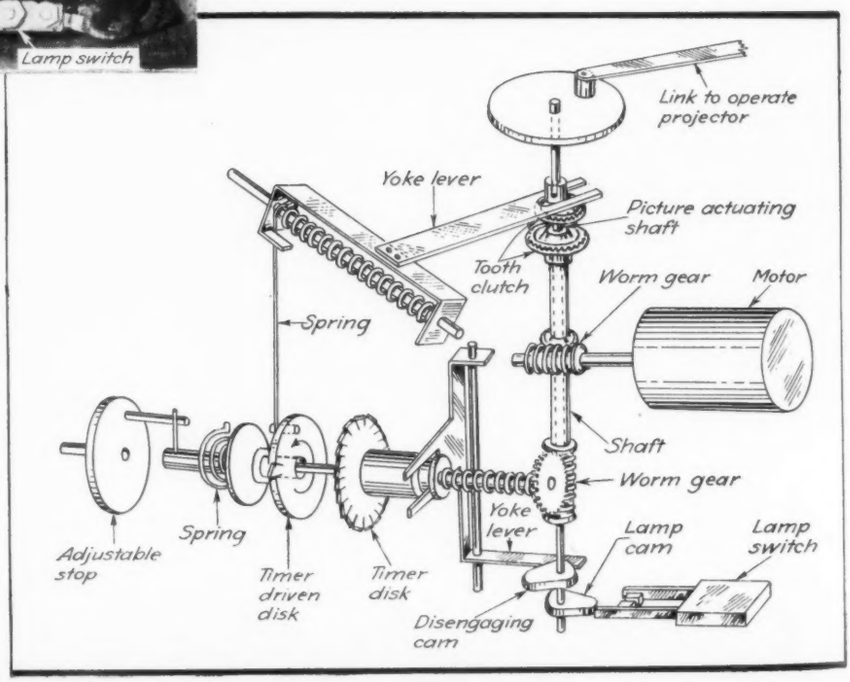
Continuous Slide Film Projector Has Electrical Timing Device

SYNCHRONOUS MOTOR times the period of projection and then advances the film to the next frame in the continuous slide film projector designed and manufactured by Transfilm Incorporated, New York. The device was used by the U. S. Navy as a quizzer to check both speed and accuracy of personnel in identifying enemy aircraft. Projector is a standard SVE model to which a ratchet mechanism has been added so that the timing device can also advance the film to the next frame after a predetermined exposure period. Timer adjustment is mounted at the back of the housing as are the lamp and timer switches. Space is also provided for the electric cord.



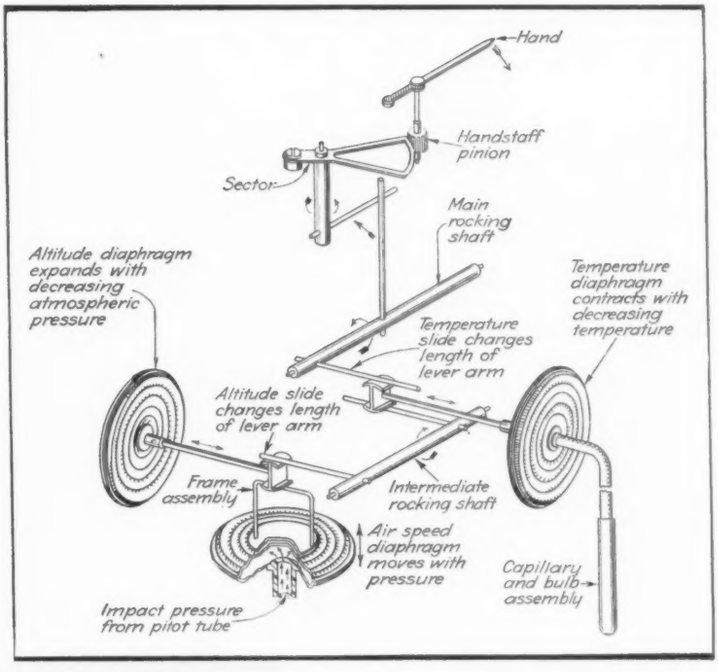


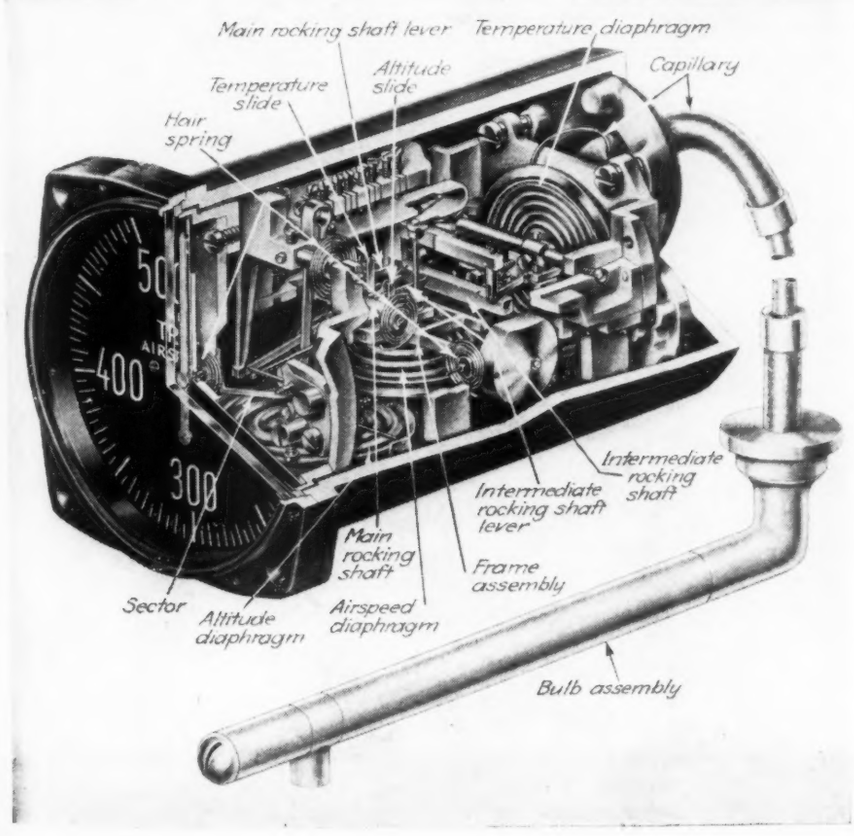
Timer is driven by a synchronous electric motor that also advances the slide film to next frame. Motor drives a shaft that in turn actuates the timer disk through two worm gears. Timer disk has thirty tabs that can contact a single tab on the timer driven disk. As timer-driven disk is rotated, a pin on it contacts the extension of a helical spring carried in a yoke that has a lever mounted on it. **Movement of lever** causes engagement of a tooth clutch drive from main shaft to film-feed shaft, which then rotates one revolution. At end of one revolution, disengaging cam film-feed shaft disengages timer disks through a yoke lever. Second cam, also on the picture-actuating shaft, extinguishes the projector lamp during changing of pictures.



Bellows Expansion Changes Leverage

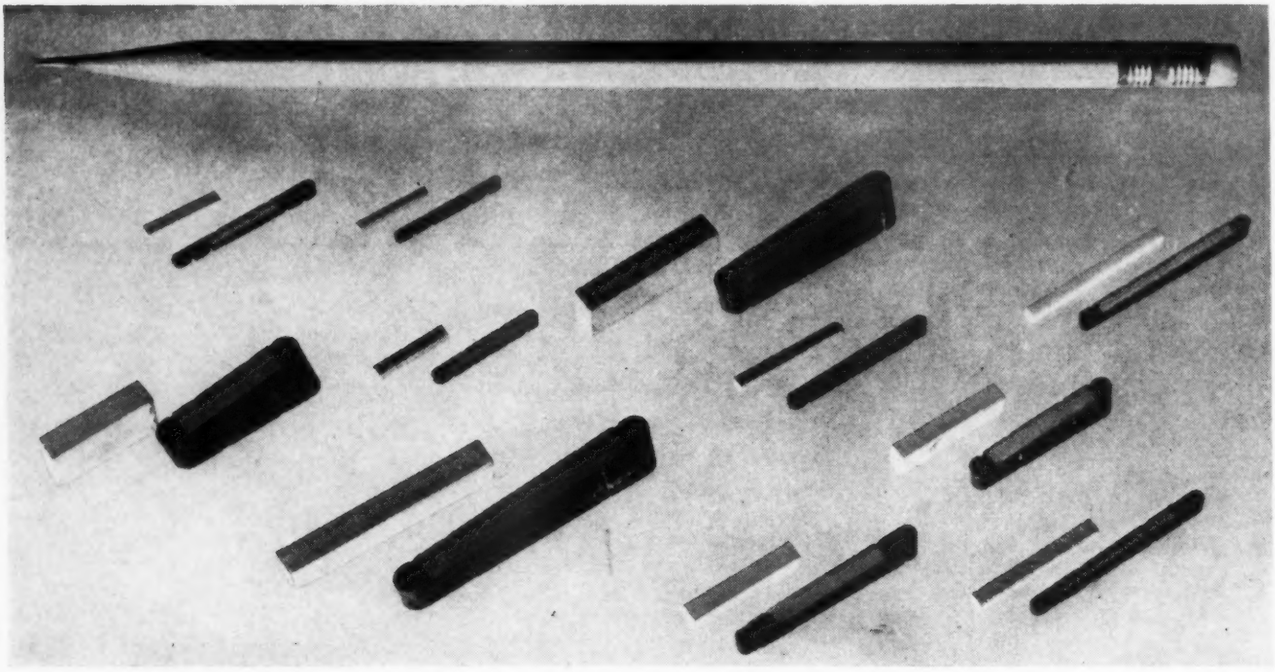
THE TRUE AIRSPEED at which an airplane is flying is instantly shown by the True Airspeed Indicator, a wartime development of Kollsman Instrument Division of the Square D Company, Elmhurst, N. Y. The instrument consists of three basic, interacting diaphragms—airspeed indicator, altimeter, and air thermometer—that automatically correct for changes in air density and the effect of the compressibility of air at high speeds on the Pitot tube and temperature bulb.


Hand
Handstaff pinion
Sector
Main rocking shaft
Altitude diaphragm expands with decreasing atmospheric pressure
Temperature diaphragm contracts with decreasing temperature
Temperature slide changes length of lever arm
Altitude slide changes length of lever arm
Frame assembly
Intermediate rocking shaft
Air speed diaphragm moves with pressure
Capillary and bulb assembly
Impact pressure from pilot tube



Impact air pressure, picked up by Pitot tube, causes airspeed diaphragm to expand against a lever, successively moving the intermediate rocking shaft, main rocking shaft, sector, hand staff pinion and hand. The altitude diaphragm and temperature diaphragms insert corrective factors in this train. All elements in the case are surrounded by static pressure brought into the otherwise airtight case by the static pressure line. As the pressure decreases with increase in altitude, the altitude diaphragm expands, moving the altitude slide so as to shorten the length of the lever arm that turns the intermediate rocking arm. The change in length of lever arm is calibrated to the altitude. Atmospheric temperature similarly affects the temperature diaphragm.

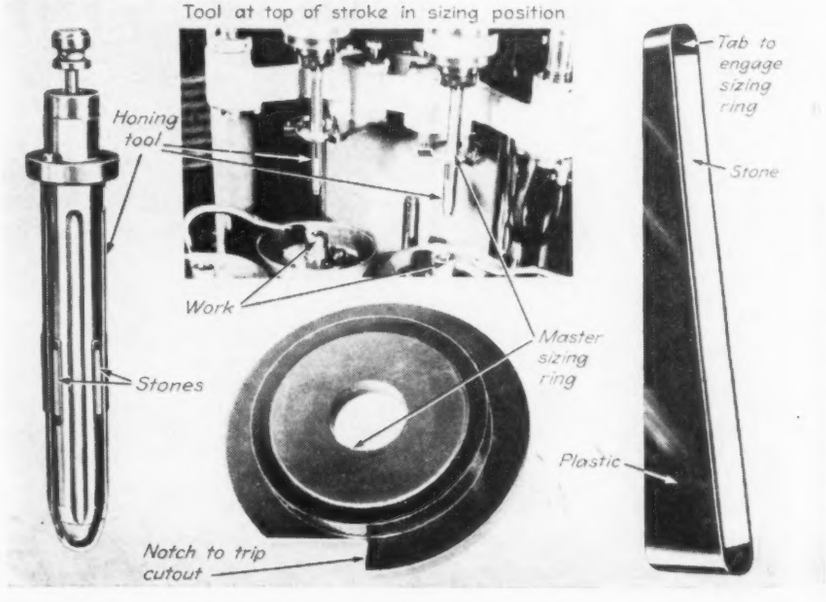
Low friction pivot points of hardened steel pinions and jewel bearings are used because no oils are available that give equal lubrication throughout the extremes of temperature encountered. Five hairsprings compensate for backlash. Compressibility phenomena is corrected by the instrument actuating intakes mounted outside the plane.

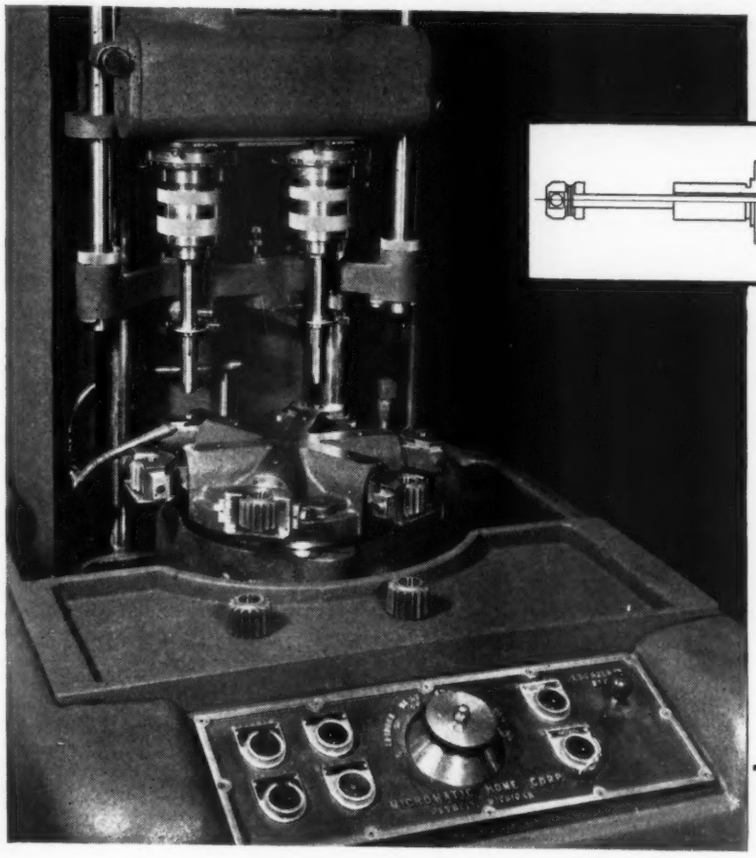


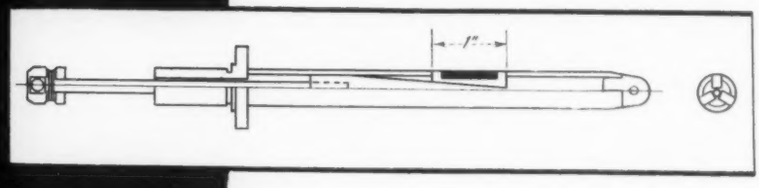
Abrasive Sticks in Plastic Wedges Facilitate Automatic Bore Sizing

BONDED ABRASIVE STICKS, reinforced underneath with a steel strip, encased with stone side open in transfer molded rectangular plastic wedges enable the Micromatic Hone Corporation, Detroit, to use a master sizing ring that controls final cylinder bore size to uniform accuracy. The phenolic thermosetting resin used resists wear and chemical action of honing coolants. The stones withstand pressures as high as 3,000 lb. per sq. in. Smaller bores can be honed with plastic stoneholders than with the usual sheet metal shell shaped holders because thinner and shorter stones can be used. Stick sizes range from a minimum of 0.093 in. wide x 0.075 in. high x 1/4 in. long to a maximum of 5/16 x 5/16 x 4 in. Abrasive travel rates range from 40 to 150 surface-feet per min., depending on the material being honed.

Master sizing ring automatically checks bore size at the end of each honing stroke when the plastic tab on the stone holder enters the ring. The stone does not touch the surface of the master sizing ring, but because the plastic mount wears at the same rate as the stone, tab diameter is a measure of stone diameter. When the stone expands to the prescribed diameter size, the plastic tab binds in the master sizing ring. This causes the sizing ring to revolve until the notch in the ring trips an electrical control unit that stops further stone expansion on that particular spindle.







Three stones are positioned in the honing tool. These stones expand radially in the tool to maintain cutting action as the bore diameter increases and to compensate for the wear of the stone. The honing tool rotates and reciprocates throughout the length of the preset stroke. A floating master sizing ring is positioned on the machine spindle head to control final bore size.

Random Notes

An electrically operated artificial arm has been devised by the International Business Machine Corporation, Rochester, N. Y., as a development to aid veterans who lost a limb in the war or in industrial accidents.

* * *

Northrup Aviation Company, Hawthorne, Calif., has also developed an artificial arm. The arm weighs two pounds, has an automatic elbow locking mechanism, and a hook. Work has begun on a mechanical hand to replace the unsightly hook. This company has also developed an artificial leg with a suction mechanism that would make unnecessary the cumbersome harness now used. An hydraulic system to control knee action, developed in Germany, is being studied by the Prosthetics Advisory Counsel of the Veteran's Administration. There is still a great need for development and research in the field of prosthetics.

* * *

A new automobile finish, metallic-chrome, pyroxylin lacquer, extremely durable and providing rich and lustrous color effects has been developed by E. I. DuPont de Nemours & Company, Wilmington, Del. The film is translucent so that light penetrates it and is reflected to the eye from within, instead of from the surface of the finish. Small particles of aluminum act as tiny mirrors diffusing and refracting light within the film so as to produce a glowing effect. These translucent metallic finishes present to the eye considerable color variation as the lighting alters or the angle of one's vision shifts. For example, a reddish-brown changes all the way to a grey brown upon certain conditions, and what appears to be a deep black in subdued light becomes a warm gun-metal shade in the sun.

* * *

Powdered metal bearings are cold pressed by the National Diamond Hone & Wheel Company of New York City. Because sintering equipment is not required, the cost of these cold pressed metal bearings is low. The bearings have been produced from copper-nickel-tin, silver-copper-lead, aluminum-copper, copper-nickel-lead. The bearings have low tensile strength or impact resistance. They are not recommended where a bearing pressure is heavy or where the loads are applied suddenly. The compressive strength of the material is high.

* * *

An electro-plated heavy duty engine bearing has been developed by Cleveland Graphite Bronze Company. Bearing was designed primarily for gasoline and Deisel engines in trucks, buses and tractors where loads exceed the capacity of previous types of bearings.

* * *

An alloy of 75 percent beryllium and 25 percent aluminum, having about half the weight of aluminum is now being used for parts that must be as light and strong as possible and where cost is not a factor.

* * *

Wooden bearing retainers of compressed molded veneer were used in Germany during the war. German tests indicated that they were decidedly superior to metal retainers.

Spot Weld Strengths and Structures Of 75ST Alclad Aluminum Alloy

MARIO L. OCHIEANO
Production Methods Engineer, Lockheed Aircraft Corporation

Preparation of surfaces for spot welding, effects of aging on types of weld failures, and hardness surveys of spot welded areas. The strengths and structures of spot welds in 75ST Alclad aluminum alloy are compared and correlated with the corresponding properties of 24ST alloy.

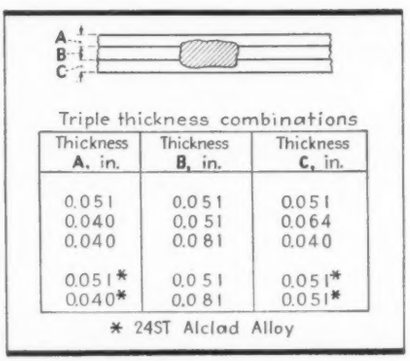
MORE THAN 900 spot welded specimens of 75ST Alclad aluminum were tested to failure to determine the tensile and shear strengths of the welds and to compare them with the corresponding strengths of welds in 24ST Alclad aluminum alloy. Immersion times in cleaning and etching fluids for obtaining weldable surfaces were established. The specimens were examined for character and structure of the weld. Brief restatements of some of the conclusions of the tests are as follows:

1. Spot welds in 75ST Alclad aluminum alloy can be made to have satisfactory sheer and tensile strengths.
2. The ratio of tensile to shear strengths is indicative of ductile welds, the tensile being greater than 25 percent of the shear strength.
3. Thickness ratios of 2 1/2 to 1 and multiple thicknesses of sheet can be satisfactorily spot welded.
4. Combinations of 75ST and 24ST Alclad can be satisfactorily spot welded.
5. Longer cleaning and etching times are required for the 75ST than for the 24ST alloy. The time between etching and welding should be short.
6. Corona bonding is obtained on the 75ST alloy. The bonding of the corona area is chiefly affected by surface preparation and the time of exposure to the atmosphere after cleaning.
7. The 75ST alloy requires higher weld pressures than normally used on 24ST.
8. Spot weld pattern, joint designs and strengths commonly applied to the 24ST alloy, are also applicable to the 75ST alloy and are suitable for design purposes.

Shear and Tensile Strengths

Shear test data of spot welds are given in Tables I and II. Spot welds were made between pieces of 75ST alloy, both equal and unequal in thicknesses, and between pieces of 75ST and 24ST alloy. Many of the shear test specimens were spot welded as panels. Fig. 1 shows the dimensions of the panels and the positions of the welds. Some single spot weld specimens were made too, mostly when the 75ST alloy was joined to the 24ST alloy. Also, triple thickness specimens were tested and examined. Fig. 2 gives dimensions of these specimens, some of which were cross-sectioned, etched and mounted, and observed under magnification.

Four types of failures occurred. Fig. 3 illustrates the type and Table II lists representative numbers of failures of each type. The presence of corona bonding was confirmed by failures during the shear tests. Failures of the corona bond, which was indicated by a clear snapping sound, occurred just prior to 100 percent load. Immediately afterward, the weld nugget failed partly in shear and partly by pulling out around its periphery, Type 3, Fig. 3. About 90 percent of the failures were of this type; the remainder were Type 1, or pure shear failures.



Triple thickness combinations

Thickness A, in.	Thickness B, in.	Thickness C, in.
0.051	0.051	0.051
0.040	0.051	0.064
0.040	0.081	0.040
0.051*	0.051	0.051*
0.040*	0.081	0.051*

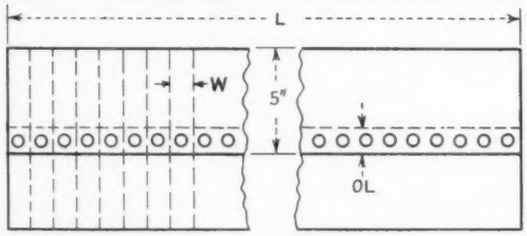
* 24ST Alclad Alloy

Fig. 2—Specimens consisting of three pieces spot welded together were made up as indicated here.

Test data on the failures of spot welds in tension are contained in Tables II and III. The spot weld was made on a U-shaped specimen, Fig. 4(A). Tensile specimens of the dimensions shown on Fig. 4(B) were used in checking the physical properties of the aluminum sheet.

Tensile test specimens were cut from the same sheets of aluminum that the pieces for the spot weld specimens were taken from. Specimens both with and across the grain were tested in checking the physical properties of the sheet. Table IV contains representative test results.

Closely controlled preparation of the



Panel dimensions as a function of sheet thickness

Material thickness, in.	Dimension L, In.	Dimension W, In.	Dimension OL, In.
0.025	19	5/8	3/4
0.032	23	3/4	3/4
0.040	23	3/4	3/4
0.051	30	1	1
0.064	30	1	1
0.072	38	1 1/4	1 1/4
0.081	38	1 1/4	1 1/4

Fig. 1—Many shear specimens were spot welded in panels and then band sawed into separate test specimens.

Table I—Summary of Shear Strengths of Pieces of 75ST Alclad Aluminum Spot Welded Together and to Pieces of 24ST Alclad Alloy

Material Thicknesses, In.	Ultimate Strength, lb. per weld			Number Specimens Tested	Number Specimens Within 10 Percent of Average
	Max.	Min.	Avg.		
0.025 and 0.025	350	250	277	50	42
0.032 and 0.032	420	290	365	25	21
0.040 and 0.040	595	415	529	50	44
0.040 and 0.040*	620	350	511	25	19
0.051 and 0.051	755	550	674	25	20
0.064 and 0.064	1100	900	1006	50	49
0.072 and 0.072	1195	965	1121	25	23
0.081 and 0.081	1435	1120	1332	25	22
0.025 and 0.064	410	350	383	30	30
0.064 75ST and 0.051 24ST	750	570	682	25	21
0.081 75ST and 0.051 24ST	940	725	826	25	21

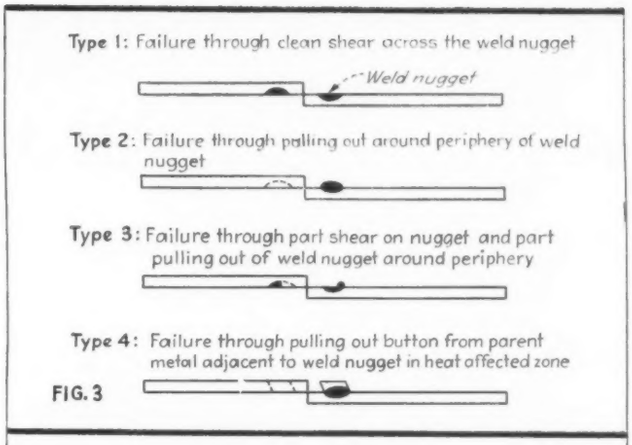
*Etched with hydrofluoric acid before welding on Sciaky welder.

Table II—Summary of Types of Failures

Material Thicknesses, in.	Type of Failure				Nugget Diameter, in.	Corona Width, in.	Corona Diameter Including Weld Nugget, in.
	1	2	3	4			
Shear Specimens							
0.025	6	0	3	71	0.135	0.02	0.175
0.025 and 0.064	19	0	0	6	0.14	0.02	0.18
0.032	4	4	16	1	0.146	0.037	0.22
0.040	46	7	9	24	0.17	0.037	0.235
0.040	22	0	2	1	0.16	0.05	0.26
0.051	23	0	2	0	0.19	0.045	0.28
0.064	71	0	8	0	0.22	0.06	0.34
0.072	25	0	0	0	0.24	0.06	0.36
0.081	25	0	0	0	0.25	0.065	0.38
Tensile Specimens							
0.025	0	0	0	50	0.135	0.02	0.175
0.040	0	45	0	5	0.16	0.037	0.235
0.064	0	33	0	15	0.22	0.06	0.34

Table III—Strength in Tension of Spot Welded 75ST Alloy

Material Thickness, In.	Ultimate Strength, lb. per Weld			Number Specimens Tested	Number Specimens Within 10 Percent of Average	Ratio of Tensile to Shear Strength
	Max.	Min.	Avg.			
0.025 and 0.025	95	55	76	25	23	28.2
0.040 and 0.040	285	140	174	25	18	32.7
0.064 and 0.064	425	295	356	25	17	35.4


Type 1: Failure through clean shear across the weld nugget
Weld nugget
Type 2: Failure through pulling out around periphery of weld nugget
Type 3: Failure through part shear on nugget and part pulling out of weld nugget around periphery
Type 4: Failure through pulling out button from parent metal adjacent to weld nugget in heat affected zone
FIG. 3

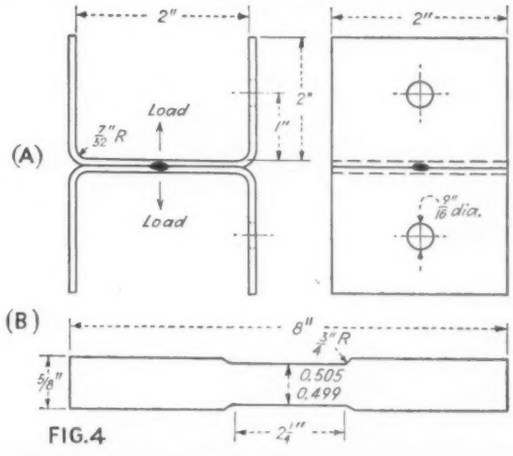


FIG. 4

Fig. 3—Diagrams showing four patterns into which the failures are classified. Fig. 4—(A) Tensile strengths of spot welds were found from U-shaped tensile specimens; (B) Ordinary tensile specimens were used in obtaining the tensile strength of the material for comparison.

Table IV—Properties of 75ST Alclad Aluminum Alloy

Material Thickness, in.	Grain Direction	Stress at Failure			Minimum Values		
		Ultimate Tensile, lb. per sq. in.	Ultimate Yield, lb. per sq. in.	Elongation in 2 in. per cent	Tensile, lb. per sq. in.	Yield, lb. per sq. in.	Elongation in 2 in. per cent
0.025	With	81,300	73,000	11.5	70,000	60,000	7
0.025	With	80,400	72,600	10	70,000	60,000	7
0.025	Across	77,400	66,000	8	70,000	60,000	7
0.025	Across	79,900	68,000	9.5	70,000	60,000	7
0.040	With	77,700	69,600	12.5	72,000	62,000	8
0.040	With	78,000	69,900	13.5	72,000	72,000	8
0.040	Across	75,500	64,500	8	72,000	62,000	8
0.040	Across	76,200	64,700	14	72,000	62,000	8
0.064	With	78,600	75,300	14.5	72,000	62,000	8
0.064	With	75,800	72,800	14	72,000	62,000	8
0.064	Across	79,000	69,200	12	72,000	62,000	8
0.064	Across	77,100	69,800	6	72,000	62,000	8

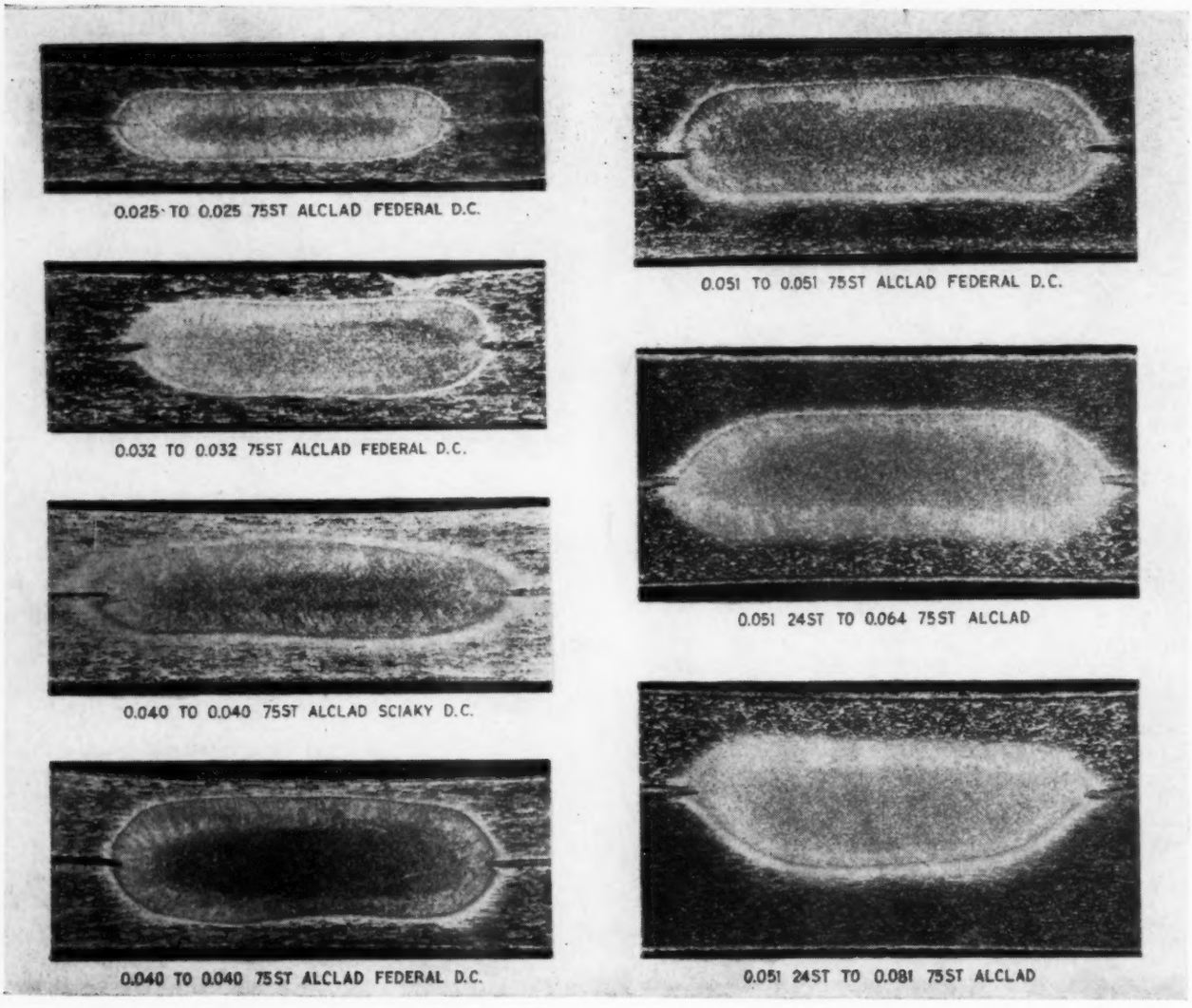

0.025 TO 0.025 75ST ALCLAD FEDERAL D.C.
0.051 TO 0.051 75ST ALCLAD FEDERAL D.C.
0.032 TO 0.032 75ST ALCLAD FEDERAL D.C.
0.051 24ST TO 0.064 75ST ALCLAD
0.040 TO 0.040 75ST ALCLAD SCIAKY D.C.
0.040 TO 0.040 75ST ALCLAD FEDERAL D.C.
0.051 24ST TO 0.081 75ST ALCLAD

Fig. 5—From photomicrographs of spot welds in materials of different thicknesses.

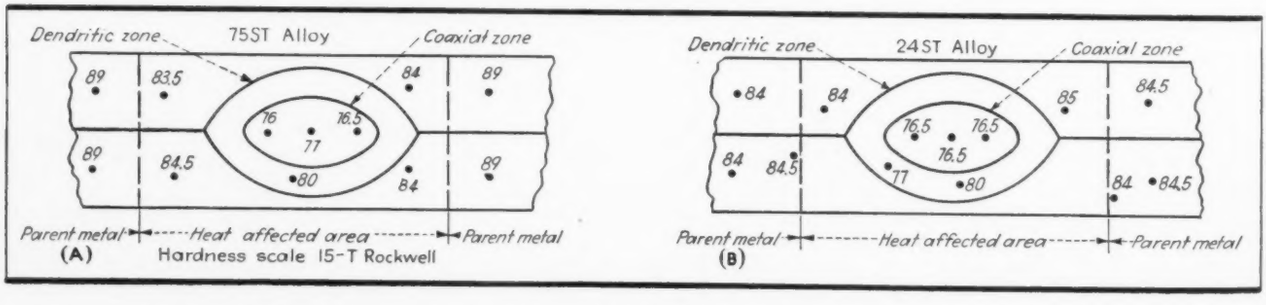


Fig. 6—Results of hardness survey of weld in 75ST alloy compared with weld in 24ST alloy.

surface for spot welding and short atmospheric exposure after preparation are essential to good welds. Low, uniform resistance between the surfaces to be welded is favorable to producing a good corona bond. All welding was completed within four hours after cleaning.

Surface preparations that produce round, consistent button diameters, free of internal surface flashes and tip pick-up, are not necessarily indicative of properly prepared surfaces. This was discovered when some specimens, which had been welded under identical conditions with others that were unbuttoned and examined, gave inconsistent test results after salt spray. Close observation of all the weld nuggets revealed the presence of bonding throughout the corona area.

Character of Weld

All the spot welds between pieces of 75ST alloy and in combinations with the 24ST alloy showed good weld structure, geometry and penetration. As indicated in Fig. 5 the sheet separation was small. This separation was likewise small for specimens composed of three thicknesses.

The over-all diameter of the weld in 75ST alloy was larger than that in 24ST alloy but its nugget diameter was smaller when welds made under identical conditions were measured and compared. This indicates that more heat during welding went into the formation of the weld nugget in the 24ST alloy, while in the 75ST speci-

men less heat passed through the central region and more through the corona area in comparison.

This is significant because it explains the better corona bonding of the 75ST alloy. Bonding is aided further by the increased specific resistance and the slightly lower fusing point of the alloy clad coating.

In comparing the hardnesses of different zones of the weld in 75ST alloy, Fig. 6, with those in 24ST alloy the following observations are made:

1. The coaxial and dendritic or columnar structures showed the same hardness readings in both welds.

2. The 75ST parent metal, unaffected by the heat of welding, showed a greater hardness than the 24ST alloy.

3. The heat affected area (corona area) showed a decrease in hardness of 75ST Alclad alloy. This decrease was evident from the end of the corona diameter up to the weld nugget. The hardness of the 75ST corona area was the same as that of the 24ST parent metal.

Immediately after welding, button pull-out failures, similar to those obtained on 24ST alloy, are obtained for the 75ST alloy. But after aging for approximately two weeks, failures of the type shown by Fig. 7 (*B*) are obtained. The cause for this failure along the entire outside edge of the cast periphery is not immediately apparent, although it indicates that the aging affects the zone immediately adjacent to the weld nugget.

Regions through part of the nugget and corona area in three 0.051-in. thicknesses of 75ST alloy are shown in Fig. 7(*A*). Penetration of the weld nugget into the top and bottom sheets was approximately 65 percent of the sheet thickness. No porosity was evident in the cast structure.

Penetration of the weld nugget into the top and bottom sheets was approximately 50 percent of sheet thickness when three 0.051-in. thicknesses of 75ST and 24ST alloy were spot welded. Slight microscopic porosity was evident.

The 75ST Alclad alloy exhibits the same tendencies toward porosity, cracking and flashing or spitting of the metal as the 24ST alloy. Porosity and shrinkage cracks are evident in the welds when insufficient and improperly applied forge pressures are used. The factors that produce cracks, porosity and flashing are:

1. Extremely high rates of increase in current.

2. Welding current excessively high in magnitude and short in duration.

3. Insufficient welding or forge pressure or both.

4. Insufficient cooling of the outside surface by the electrode during the fusion.

The corrective measures applicable to the 24ST Alclad alloy are effective in avoiding the same kind of flaws in the 75ST Alclad alloy. Pressures of from 20 to 25 percent higher than normally used on the 24ST Alclad alloy are recommended for the 75ST alloy.

Both a Federal condenser discharge welder and a Sciaky magnetic discharge welder were used in making the spot weld specimens. Table VI supplies most of the data, including the weld pressures, pertinent to welding procedure in preparing the spot weld specimens.

Most of the specimens were cleaned before spot welding as follows: Immersion in soap cleaner at 180 deg. F. for 7 min., rinsed in water at 150 deg. F. both before and after etching in an Oakite 84A solution, 6 oz. per gal., at 180 deg. F. for 5 or 7 min. and dried by hot air.

Table VI—Some Machine Settings for Federal D.C. Laboratory Welder That Was Used in Making Many of the Spot Welds

Function or Setting	Material Thickness, in.								
	0.025 and 0.025	0.025 and 0.064	0.032 and 0.032	0.040 and 0.040	0.051 and 0.051	0.072 and 0.072	0.081 and 0.081	0.064 and 0.051*	0.081 and 0.051*
Weld button diameter	0.135	0.140	0.146	0.16	0.19	0.24	0.25		
Primary voltage, volts	2400	2800	2450	2400	2750	2800	2800	2750	2900
Number condensors	2	2	3	4	5	8	10	5	5
Microfarads	400	400	600	800	1000	1600	2000	1000	1000
Weld pressure, lb	600	600	750	950	1200	1850	2050	1200	1200
Forge pressure, lb	1150	1150	1275	1450	1800	2500	2675	1800	1800
Turn ratios	151:1	151:1	151:1	247:1	247:1	302:1	302:1	247:1	247:1
Squeeze time	0	0	0	0	0	0	0	0	0
Hold time, sec	4	4	4	4	4	6	6	4	4

* 24ST Alclad alloy.

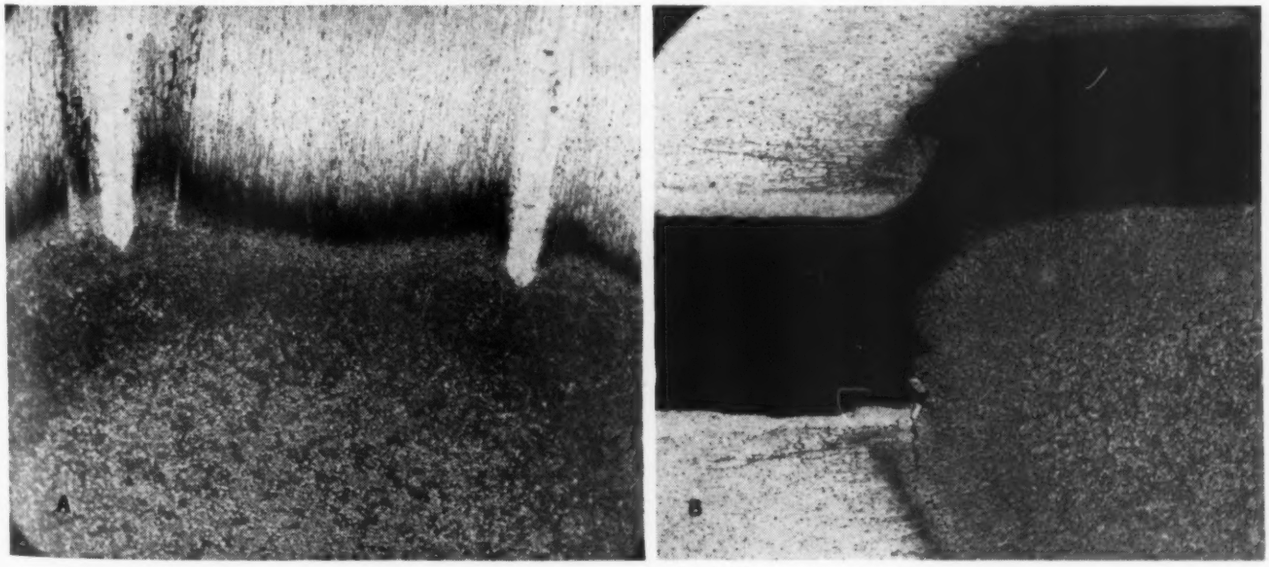
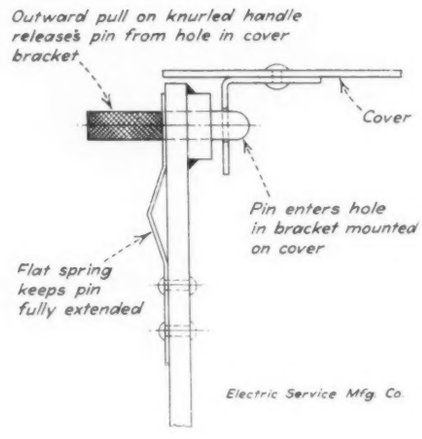


Fig. 7—(A) From micrograph of spot weld in three 0.051-in. thicknesses showing weld nugget penetration of 65 percent into outer sheets; (B) From micrograph showing button pull-out type of failure.

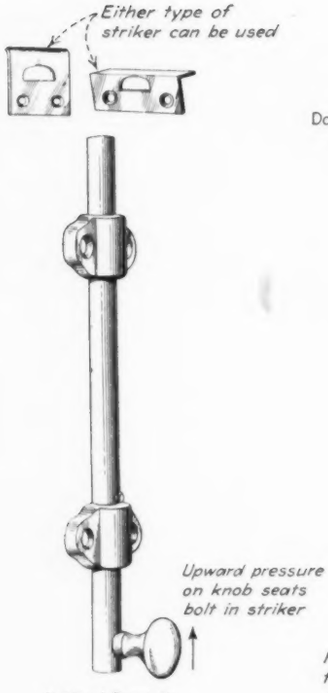
Manual and Automatic Latching Devices

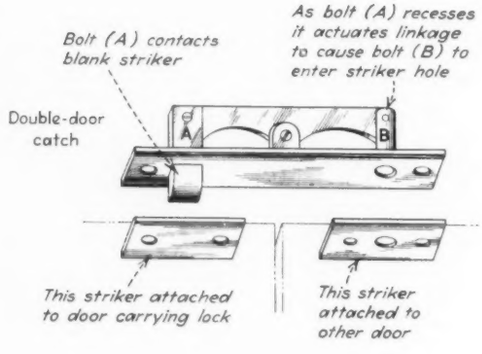
In addition to the types of latches presented in the August issue, others, classified as the bolt and draw-tight types, utilize cams, levers, and springs in their operation. Some of these are described and illustrated, each classification being subdivided according to methods of mounting, actuation, operation, and use.

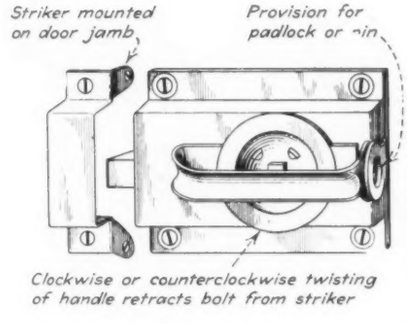
LATCHES OF THE BOLT TYPE require either manual or spring pressure for their actuation. The manual type of bolt cannot be fastened or unfastened without hand control. The spring type of bolt can generally be fastened automatically by slamming the door or cover shut, but manual effort is required to release the bolt from the striker plate.

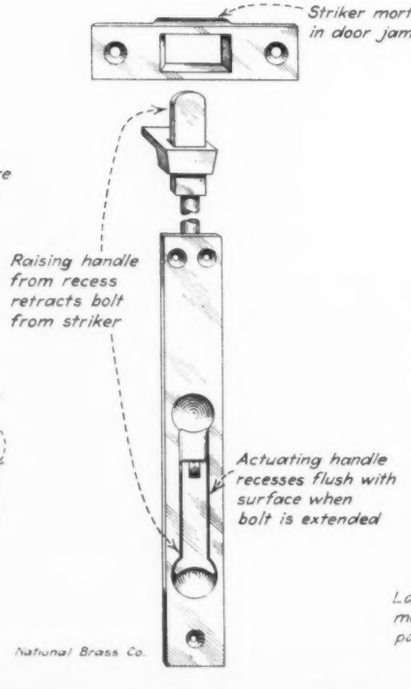

Outward pull on knurled handle releases pin from hole in cover bracket
Cover
Pin enters hole in bracket mounted on cover
Flat spring keeps pin fully extended
Electric Service Mfg. Co.

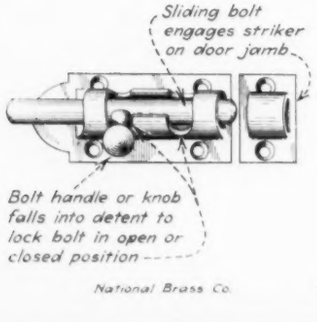
BOLT TYPE

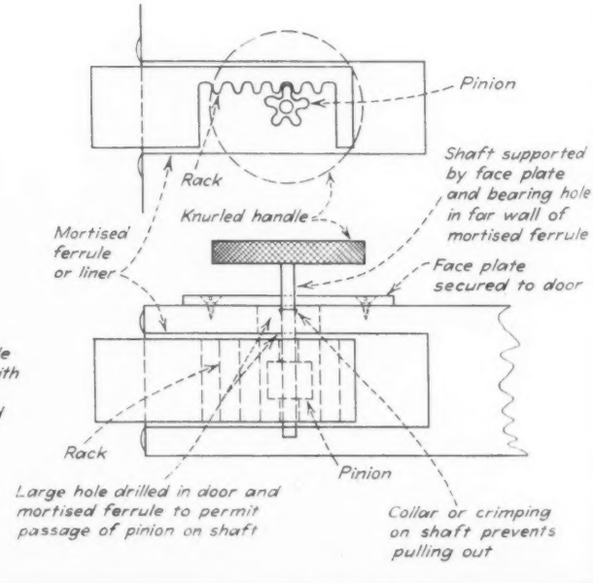



Bolt (A) contacts blank striker
As bolt (A) recesses it actuates linkage to cause bolt (B) to enter striker hole
Double-door catch
A
B
This striker attached to door carrying lock
This striker attached to other door


Striker mounted on door jamb
Provision for padlock or pin
Clockwise or counterclockwise twisting of handle retracts bolt from striker

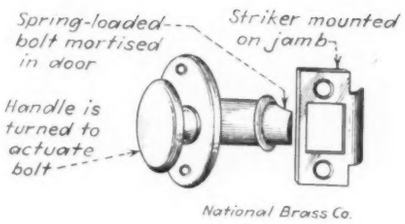

Striker mortised in door jamb
Raising handle from recess retracts bolt from striker
Actuating handle recesses flush with surface when bolt is extended
National Brass Co.


Sliding bolt engages striker on door jamb
Bolt handle or knob falls into detent to lock bolt in open or closed position
National Brass Co.

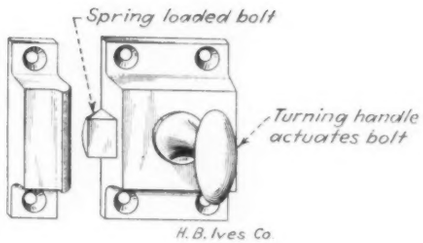

Pinion
Rack
Shaft supported by face plate and bearing hole in far wall of mortised ferrule
Knurled handle
Mortised ferrule or liner
Face plate secured to door
Rack
Pinion
Large hole drilled in door and mortised ferrule to permit passage of pinion on shaft
Collar or crimping on shaft prevents pulling out

For Doors, Covers and Lids—II

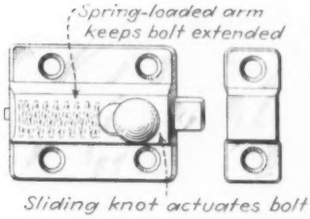
SPRING BOLT TYPE



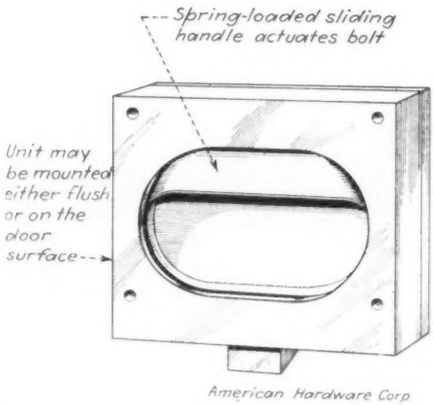
National Brass Co.



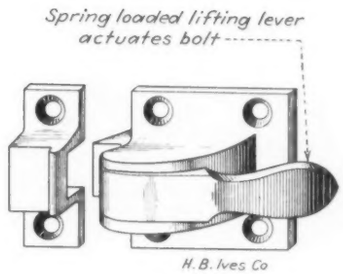
H. B. Ives Co.



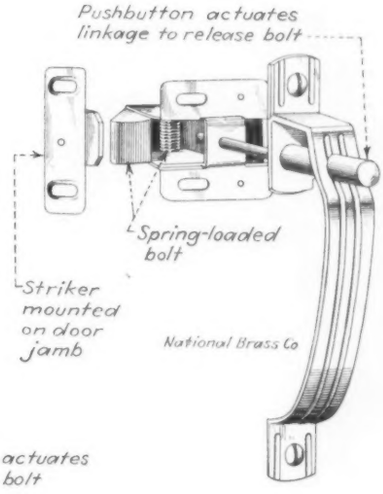
Lawrence Bros. Inc.



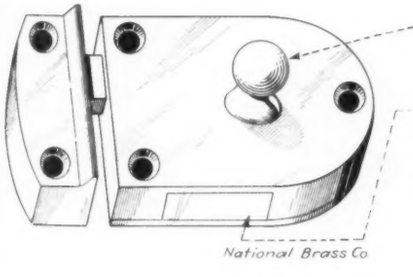
American Hardware Corp.



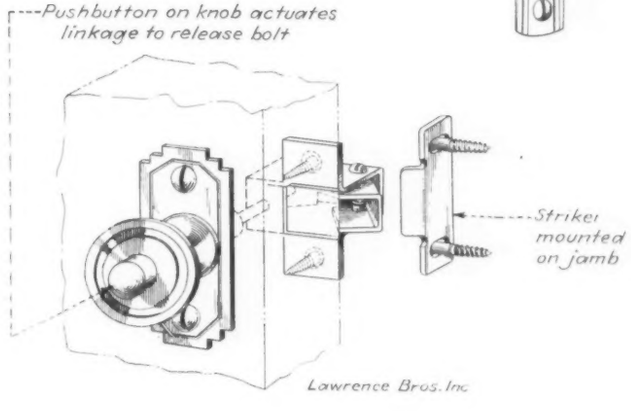
H. B. Ives Co.



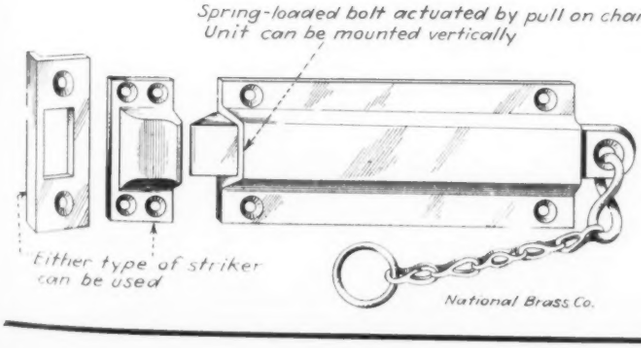
National Brass Co.



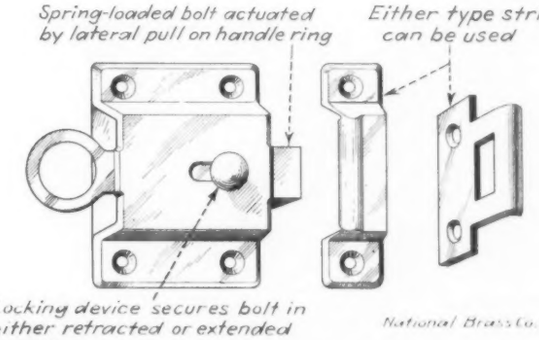
National Brass Co.



Lawrence Bros. Inc.



National Brass Co.

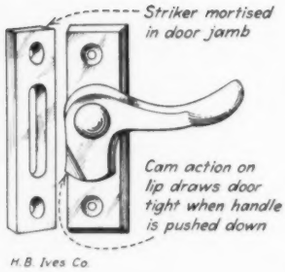

Spring-loaded bolt actuated by lateral pull on handle ring
Either type striker can be used
Locking device secures bolt in either retracted or extended position
National Brass Co.

(Continued on next page)

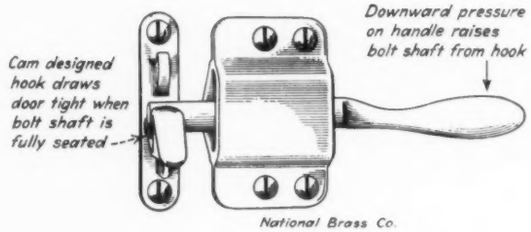
LATCHING DEVICES (continued)

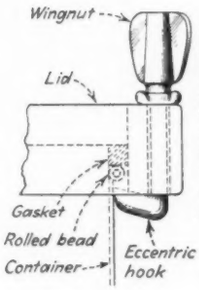
LATCHES OPERATING ON THE DRAW-TIGHT PRINCIPLE are manually operated. These latches draw the cover or door tightly against the jamb. The pressure of the door against the jamb can be increased by use of gasket material around the door or cover making the closure air, dust of water tight. The lever linkage type of latch multiplies the manual effort expended in closing the latch. The screw type of closure requires tools for latching and unlatching, but provides the tightest closure available. The cam type draws the cover or door closed with an ever increasing pressure as the latching arm follows the cam striker. The spring type draw-tight latch holds the door or cover closed.

CAM TYPE DRAW TIGHT



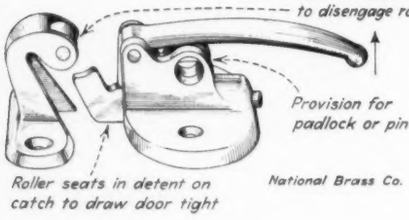
H.B. Ives Co.

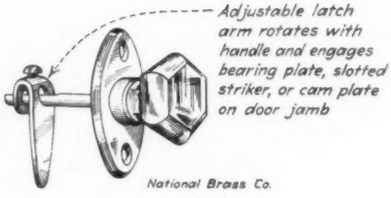

Cam designed hook draws door tight when bolt shaft is fully seated
Downward pressure on handle raises bolt shaft from hook
National Brass Co.



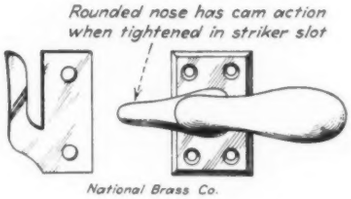
When wingnut is turned to the left, it first loosens the latch. As turning continues, friction between the wingnut and thread of hook bolt causes eccentric hook bolt to move counter-clockwise so that it no longer engages rolled bead

Electric Service Mfg. Co.


Upward pressure on handle causes catch to disengage roller hook
Provision for padlock or pin
Roller seats in detent on catch to draw door tight
National Brass Co.

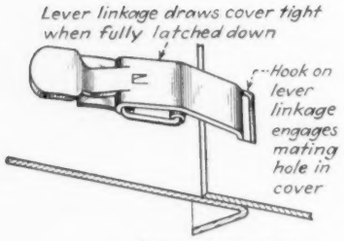


National Brass Co.

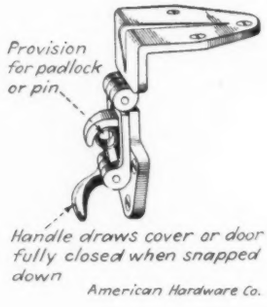


National Brass Co.

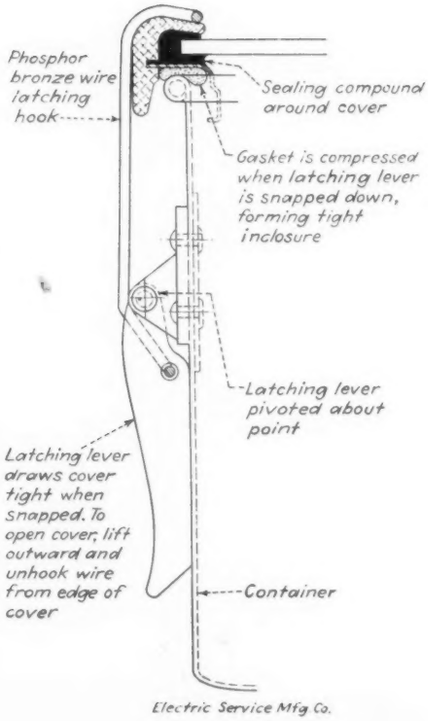
LEVER LINKAGE DRAW TIGHT TYPE

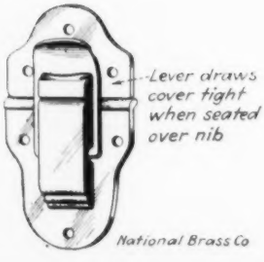


Timerman Products, Inc.

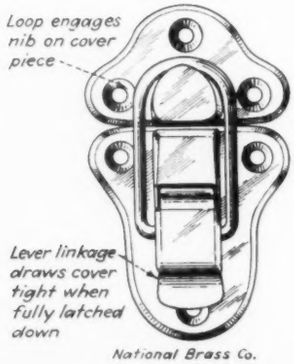


American Hardware Co.


Phosphor bronze wire latching hook
Sealing compound around cover
Gasket is compressed when latching lever is snapped down, forming tight inclosure
Latching lever pivoted about point
Latching lever draws cover tight when snapped. To open cover, lift outward and unhook wire from edge of cover
Container
Electric Service Mfg. Co.

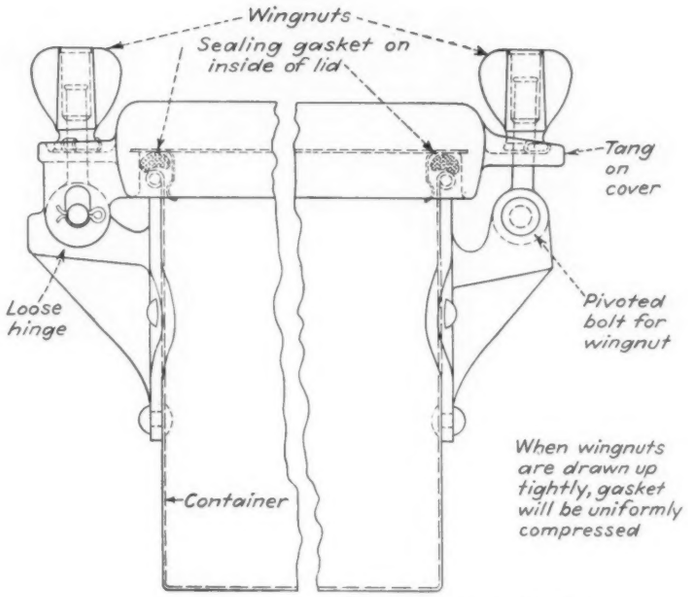


National Brass Co

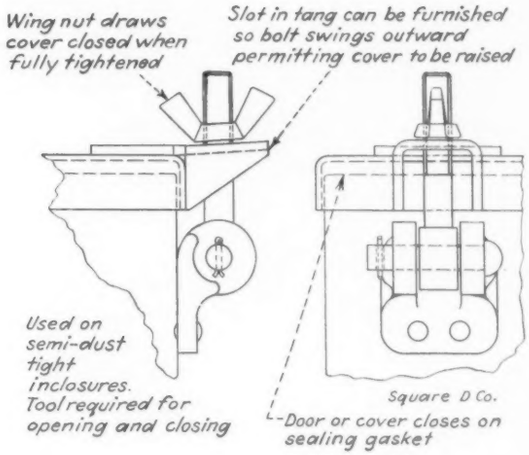


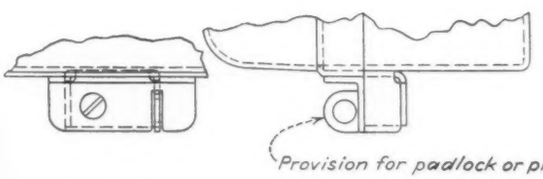
National Brass Co.

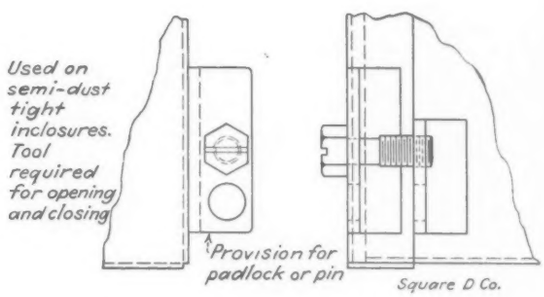
SCREW TYPE DRAW TIGHT

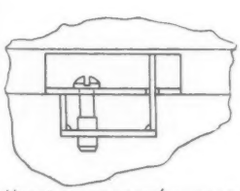

Wingnuts
Sealing gasket on inside of lid
Tang on cover
Loose hinge
Pivoted bolt for wingnut
Container
When wingnuts are drawn up tightly, gasket will be uniformly compressed

Electric Service Mfg. Co.


Wing nut draws cover closed when fully tightened
Slot in tang can be furnished so bolt swings outward permitting cover to be raised
Used on semi-dust tight inclosures. Tool required for opening and closing
Square D Co.
Door or cover closes on sealing gasket

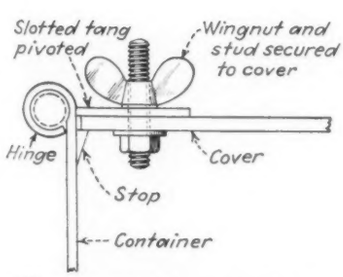






Used on general purpose inclosures having slip-on covers. Tool required for opening or closing

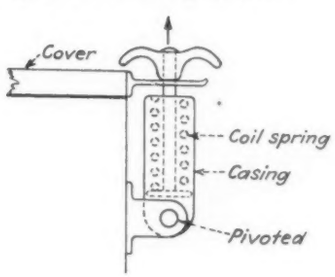
Square D Co.

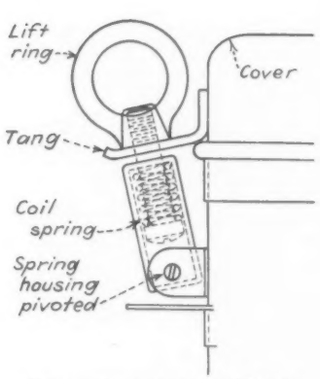


Wingnut must be removed from stud for tang to be raised and cover opened

SPRING TYPE DRAW TIGHT

Upward pressure on knob compresses internal coil spring allowing knob to be swung outward and to disengage slotted tang on cover





Upward pressure in lift ring compresses internal coil spring allowing lift ring to swing outward and to disengage slotted tang on cover

Electric Service Mfg. Co.

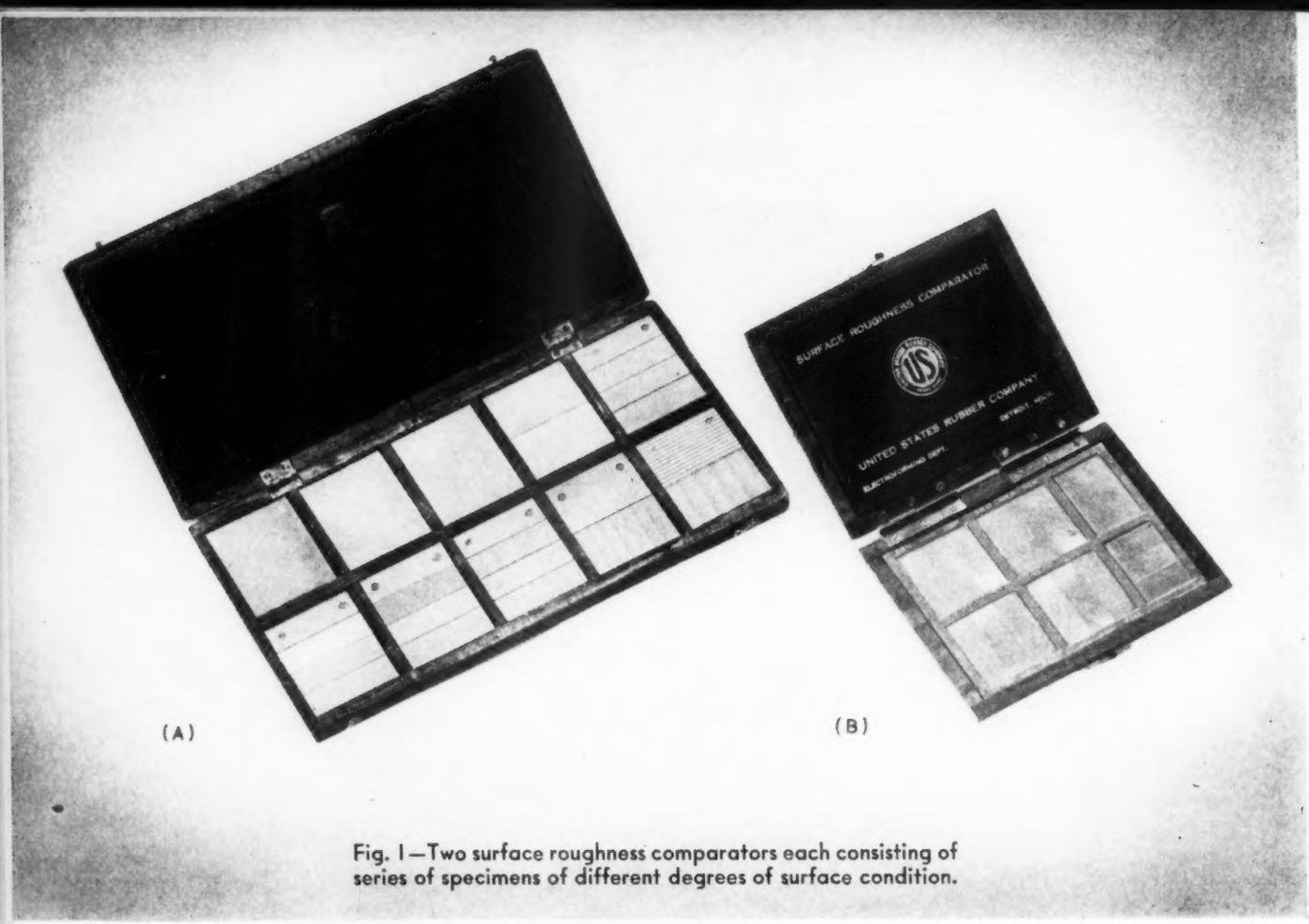


Fig. 1—Two surface roughness comparators each consisting of series of specimens of different degrees of surface condition.

A New Approach in Evaluating Surface Roughness of Gear Teeth

LOUIS D. MARTIN
Gear Engineer, Eastman Kodak Company

A proposed standard for comparing the surface roughness of teeth on fine-pitch gears is presented and its extension to a similar standard for coarse-pitch gears. The tooth surfaces resulting from three primary methods of cutting gear teeth and from four secondary methods of improving surface finish are described.

EVALUATING the condition of the engaging surfaces of gear teeth has received considerable attention for several years. It is particularly alive today because independent researchers are beginning to find out that the conditions of the surfaces play an important part in the durability of gear teeth. Before the correct surface can be prescribed for a given gear application a means of designating and duplicating surface conditions must be established. This article aims to show that the yardstick used for measuring and comparing surfaces of other machine parts cannot be used for evaluation of surface roughness of gear teeth. It also proposes a realistic means of evaluating surfaces of gear teeth that takes into account the machining processes, the limitations of the instruments generally used in measuring surface roughness and to some extent the human element.

To be useful and receive universal acceptance, a standard for evaluating the surface roughness of gear teeth will have to meet the following requirements:

1. It must be usable by the man in the shop who does the work.

2. It must be reduced to the basis of a simple visual comparison against acceptable masters.

3. The masters should have the same general configuration as the surfaces being examined. In other words, the master sur-

face must be the profile of a gear tooth.

4. The master should exhibit the waviness or lay resulting from the gear generating or manufacturing processes. A hobbed gear, for instance, will have a characteristic lay of tooth surface that is different from that produced by other methods. Even gears that have been climb hobbed have a different character of surface than those hobbed in the conventional manner. The same is true of other methods of generating and finishing the surfaces of gear teeth.

5. The standard used for visual comparison must lend itself to mass duplication without loss in definition.

Establishing a standard is not an attempt to force on the gear industry the acceptance of higher standards of finish than those it has been accustomed to produce in the past. The aim of a standard is to furnish to the industry a realistic method of evaluating surface roughness of gear teeth.

Obviously each user of gears must determine for his own applications just which grades of roughness are suitable for specific uses. Frequently designers lose sight of manufacturing costs in specifying surface roughness of gear teeth. At present the temptation exists to specify finer finishes for gear teeth than the application requires. This is largely because of an inadequate basis of evaluation. As much care and judgment will have to be used to select the proper gear tooth surface for a given application, for instance, as is used in the selection of screw threads.

Several large companies have developed standards for surface roughness of machined parts. This is admittedly inadequate for comparing the surfaces of gear teeth because the comparison is made with a standard that does not truly represent the finish obtainable on gear teeth.

Two commonly used surface roughness comparators are illustrated by Fig. 1(A) and (B). These comparators are reproduced from master blocks by an electroplating technique known as electroforming and also by the trade name Ekko Process. The United States Rubber Company were the originators of the process and are large producers of surface roughness comparators.

A preselected number of specimens, which are typical of the surface condition obtained by the various machining processes, such as turning, grinding and shaping, are made to different degrees of surface roughness. Any two adjacent specimens define a range of surface roughness that can be designated in rms microinches. These specimens are called masters. From them facsimiles are made to represent the kind of surfaces commonly used in factories and machine shops. A comparison made visually, with or without the aid of optics, is usually adequate. The essential point is that the surfaces on the masters and all the facsimiles derived therefrom are producible by present-day methods. On the contrary they do not represent the kind of surfaces found on the profiles of gear teeth and cannot be used as the yardstick for the evaluation of gear tooth surfaces.

Special Comparators Required

The surface comparator for gear teeth should have the same general configuration and appearance as the gear teeth. In fact the master must be made from a gear, since only on a gear tooth profile can the characteristic lay of the particular generating tool or process be reproduced. As a matter of fact the same generating tool will produce different degrees of finish, under the same operating conditions of the machine, along the profile of a given gear tooth.

The condition of the surface from tip to root circle of a pinion is different from that of a gear because of the difference in the sliding velocity. This is generally true of the generating methods of producing gear teeth.

Diagrammatically, Fig. 2 shows a gear tooth generated by a shaping cutter of the Fellows type. It will be seen that for the same angular movement of the cutter and work a shorter length of the cutter profile moves over a considerably longer distance of the gear profile toward the tip of the tooth. At the root of the gear tooth the conditions are reversed. Only in the region of the pitch circles do the length of the cutter and gear profiles become similar. This is known as specific sliding and is inherent to all generating methods of gear production. Specific sliding, coupled with the fact that gear cutting of the generating type do most of the cutting with the tip of the tool on the leading in side of the generating cycle, results in a better surface at the tip than at the root of the tooth. The difference in finish from tip to root is generally influenced, all other factors being equal, by the number of teeth in the gear or pinion and the pressure angle between the gear and generating tool, which are the factors affecting specific sliding. A gear having eighty teeth represents an average profile and has been arbitrarily selected as a standard profile in the proposed standard. It is quite probable that the final answer may be a range of profiles similar to range milling cutter conception where eight cutters are used to produce gears from twelve teeth to a rack.

Gear tooth surfaces produced by milling

Fig. 2—In generated involute gear-teeth the areas of contact between the tooth surface and the tool are unequal except in the region of the pitch line where they become similar. Fig. 3—Although a form milling cutter or grinding wheel fully envelops the tooth profile of a gear tooth during the machining operation, the tooth surface in region A is rougher than that in region B.

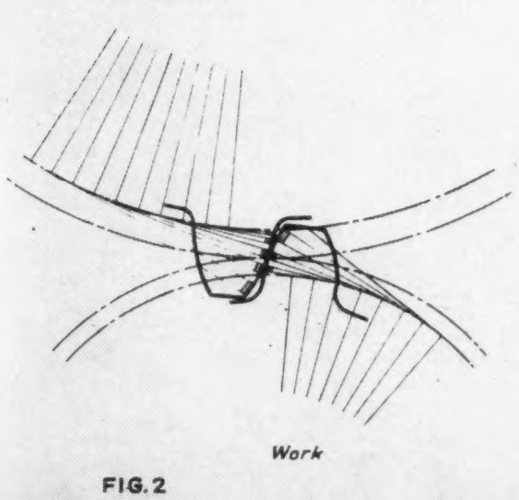


FIG. 2

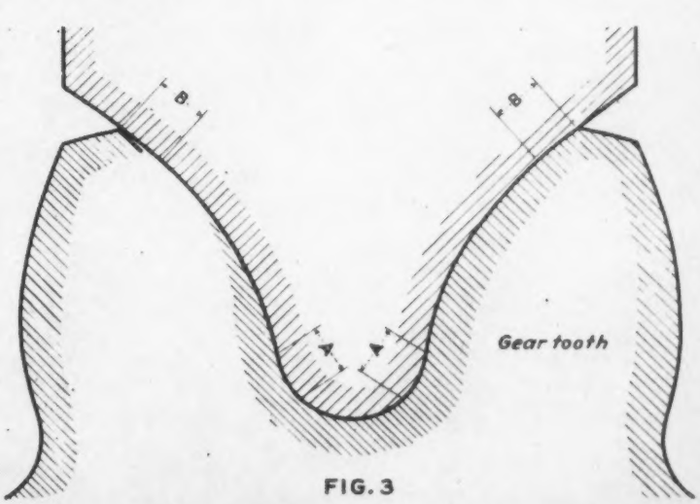


FIG. 3

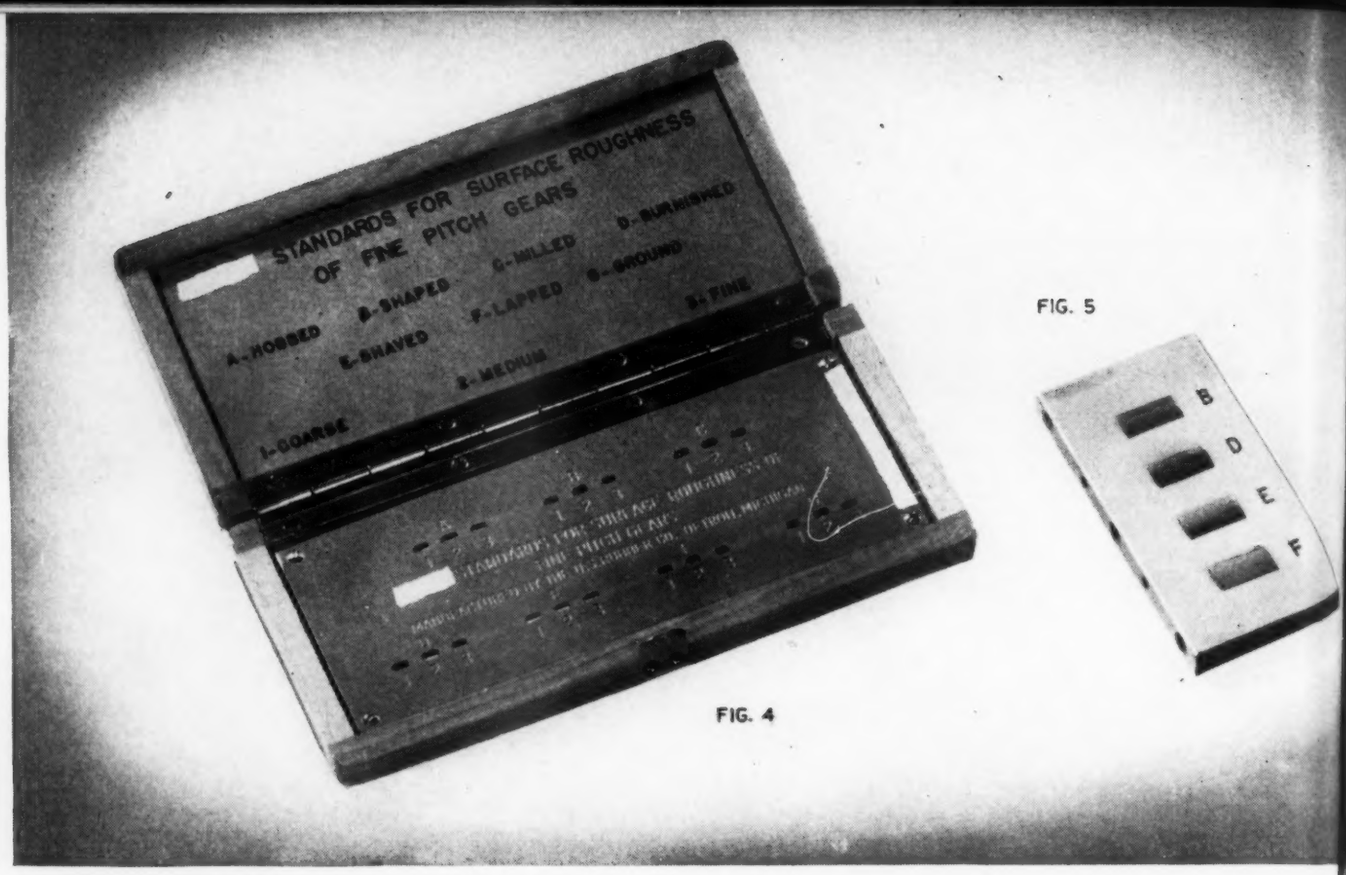


FIG. 5

FIG. 4

Fig. 4—A surface roughness comparator for fine-pitch gear representing seven different types of surface finish and three grades of surface rougnness, in each type. Fig. 5—Four specimens from 8-pitch gears illustrate the composition of a proposed standard for coarse-pitch gears similar to the fine-pitch standard.

or form grinding differ from those produced by hobbing or shaping. In the former the finish toward the tip of the gear tooth is invariably rougher than that near the root. Fig. 3 shows the profile of a gear being produced by what could be either a formed milling cutter or grinding wheel. The part of the toth near region *B* is rougher than that of region A because of a number of factors such as; higher cutting stresses, difference in cutting clearances, and to some small degree, difference in peripheral speed. The above considerations give emphasis to the fact that the production of the masters for surface roughness comparators of gear teeth must evolve about the method of manufacture of the gears whose surface they represent. There are seven currently used methods of producing and refining gear teeth: three primary and four secondary. The primary methods are: Hobbing, shaping and milling. The secondary methods are: burnishing, shaving, grinding and lapping.

Plaques containing the desired number of surface roughness specimens, which are reproduced so as to be identical with the masters, make satisfactory standards for use in the shop. The masters are made from gear teeth cut and refined on gear manufacturing equipment. The plaques can be used to make visual comparisons of the roughest acceptable surface, with or without the aid of optical instruments. A low powered magnifying glass often aids a visual comparison. If greater precision is required, such as might be desired when new standards of quality are developed, an impression of the surface of the gear to be evaluated can be made with Faxfilm or a similar substance, and compared against an impression made from the plaque. Another possibility is the use of a device known as a comparascope, which compares the surface being observed with a standard surface, but first the standard surface for gear teeth must be available.

Comparator for Fine Pitchgears

The author in collaboration with Dr. E. H. Wallace of the United States Rubber Company, Electroforming Division, developed a surface roughness comparator for fine-pitch gears, Fig. 4. The specimens, representing 21 different degrees of surface roughness on seven different types of gear tooth surfaces, are electroformed facsimiles.

Specimen gears for the masters had 80 teeth. The teeth on the masters were cut by hobbing, shaping and milling as the primary methods of manufacture. Some teeth were finished by grinding, shaving, burnishing and lapping. In each group, which is designated by letters "A" to "G" inclusive, are three classes, 1, 2 and 3, thus having twenty-one different teeth of different degrees of roughness. The degree of roughness was established from an exhaustive study made of currently used gears found in the finepitch gear industry and including every known device. They do not necessarily represent the final choice of acceptable surfaces. They are intended in their present stage, to probe the needs of the gear industry.

Since it is recognized that surface roughness is not connected with surface flaws precautions were taken in selecting the masters for reproduction to exclude teeth with surface flaws, such as isolated deep scratches, teeth with dimensional tolerances, such as profile error and flats, and teeth with waves, chatter, feed lines and diamond lines having a distance between them exceeding 0.040 inch. The only difference between one class and another in the same group is that of a change in feed, in time cycle, or both. This emphasizes the need of a separate standard for fine-pitch gears, since a feed mark of a coarse-pitch gear in some examples would be equal to, or exceed, the whole depth of the tooth. On the other hand, the same approach can be used for gears of coarse-pitch with the possible addition of intermediate sepecimens to cover wider ranges of feeds used in producing the gears.

After these twenty-one specimen profiles were developed they were inserted in a plate to form a plaque having seven groups of teeth with three classes per group. From this master plaque facsimiles have been reproduced by the electroforming process.

To explore the possibilities of evaluating the surface roughness of coarse-pitch gears, a small plaque was prepared. It should be

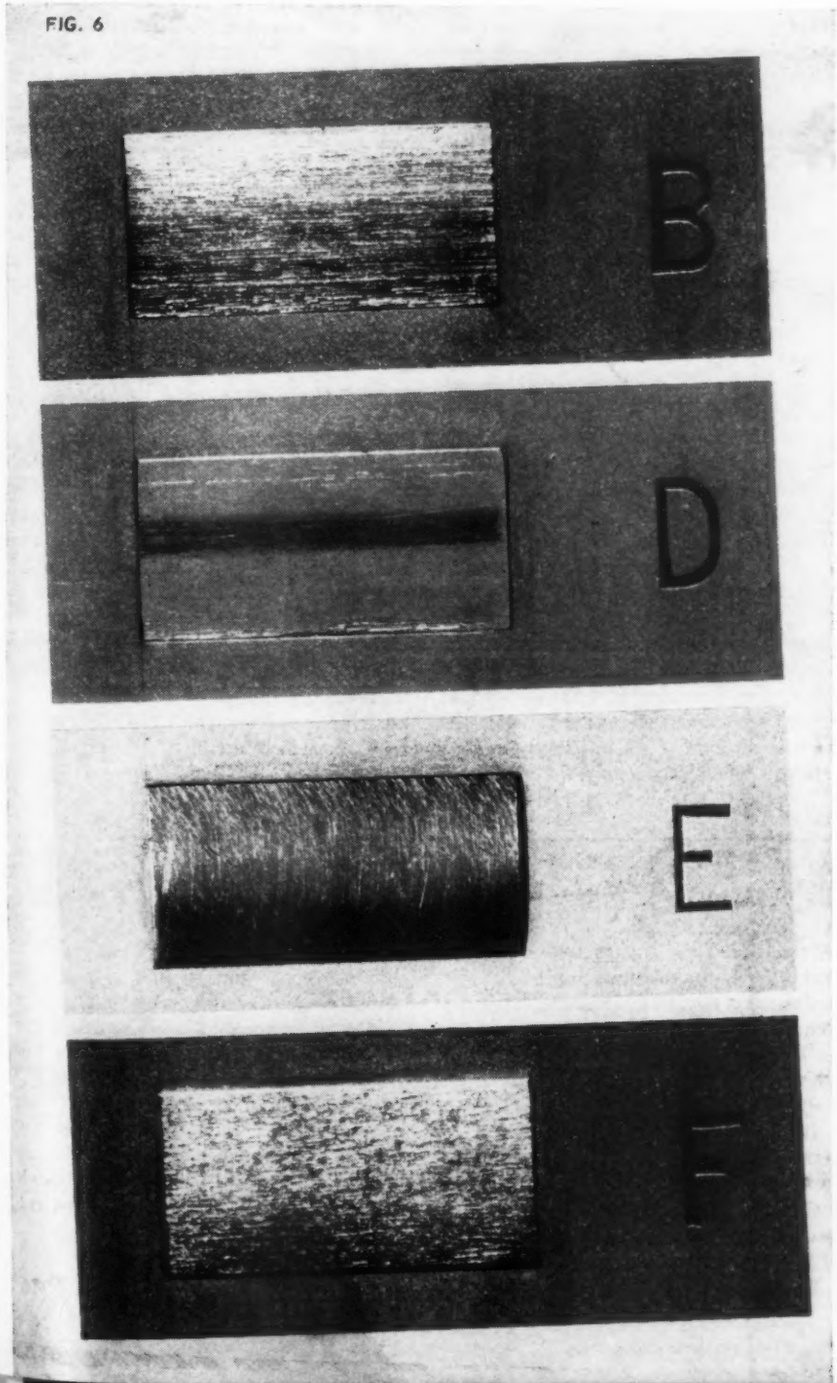
mentioned here, that the dividing line between coarse and fine-pitch gears has been arbitrarily set at twenty diametral pitch by the American Gear Manufacturers Association. Fig. 5 is a plate containing the active tooth profiles of four gear teeth. These gear teeth were taken from four, 8-pitch gears having 40 teeth and finished by the following methods: the teeth on gear *B* were shaped with a gear shaper cutter; the teeth on gear *D* were burnished after cutting ongear shaper; the teeth on gear *E* were shaved following the cutting operation; and gear *F* had teeth which were hardened and lapped following cutting.

The purpose of this plaque is to show how samples of surface roughness for coarse pitch gears might appear. The choice of pitch is purely arbitrary. It happens to be within the coarse pitch range; it is a fairly popular pitch and the company which produced the sample had the cutters, shaving tools, burnishers and laps on hand. Obviously other samples are needed to develop a complete comparator for coarse pitch gears.

An attempt was made to evaluate the surfaces of each of these four gears in microinches by means of a Brush Surface Analyzer, but without much success. A fairly consistent reading was obtained across an axial section of the teeth but readings taken in a transverse plane, that is, following the contour of the tooth profile were not reliable. This is attributed to the limitations of the instrument and to the lack of surface uniformity across the tooth profile. The readings did show a relative difference in finish, which can be confirmed by visual comparison.

Four teeth, one from each 8-pitch gear, are shown enlarged in Fig. 6, the letters *B*, *D*, *E* and *F* associating each view with the way in which the teeth were finished. Purely on the basis of an rms reading, the burnished gear, *D*, has the smoothest surface. The shaved gear *E*, although by no means as smooth as the burnished gear, has the typical surface lay of shaved gears. It is undoubtedly, in many respects, a more desirable gear in regard to accuracy than a burnished gear. Of course, it might be argued that gears can be burnished after shaving, and this technique is not as uncommon as one might suppose; it has, however, limited applications. What about hardened gears, which cannot be burnished in the final operation? The surface, *F*, is rougher than either the shaped or shaved tooth and considerably rougher than the burnished tooth.

FIG. 6



Basis for Standard

In the fine-pitch standard, surface roughness A-1 means that letter A refers to a surface produced by the hobbing process. The number 1 means that a gear made of SAE 1112 steel was hobbed with a 1-¾ diameter ground hob travelling at approximately 150 surface feet per minute and using 0.060 in. feed per revolution of the work, the hobbing machine and hob being in good operating condition. A *D*-1 quality of surface means that a gear produced as above was burnished for ten seconds in each direction between three hardened and ground burnishing gears two inches in diameter with a pressure of two pounds applied to the work by the burnishing gear.

Similarly the technique employed in producing other samples can be described and as much additional data can be given as is deemed necessary. The description of the production technique for making the original samples, while of academic interest, would be of no value to the man who uses the standard, although such information might serve as a guide for the production of gears to the same degree of surface roughness. There is nothing to prevent departure to a considerable degree from the specified procedure and still produce acceptable surfaces. The experience accumulated thus far in developing the fine-pitch plaque indicates that three grades of roughness are sufficient and that the difference between one grade and another is broad

Fig. 6—Enlarged view of the four specimens of Fig. 5. The surface on specimen B. was produced by shaping. D. burnished after shaping. E. shaved. F. hardened and lapped following cutting.

enough to permit a considerable latitude in feeds and speeds and still meet all reasonable requirements. For coarse-pitch gears more grades for each given class may or may not be desirable. This will depend on experience. It is quite likely that the specified grade that comes within the boundaries of two numbers will, for all practical purposes, be entirely satisfactory.

Specifying Requirements

In general all that needs to be done on the gear drawing is to specify the roughest acceptable finish of the end product. As

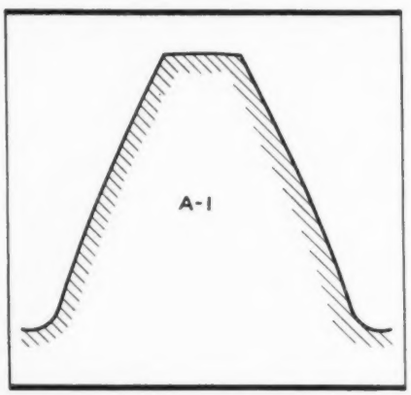


Fig. 7—On drawings the desired surface finish is specified by a letter-number symbol, in which the letter designates the kind of finish machining and the number the allowable degree of roughness.

an example: a gear is rough hobbed, finish hobbed and shaved. The surface specifications of the roughing operations are not essential since the end product is a shaved gear. The surface roughness specification would therefore be *E*-1, -2 or -3, depending on the requirements and the letter *E* being applicable to the shaving method and the number to the grade. This is in keeping with the practice already established by some companies and by government agencies. Quoting from a bulletin entitled "Ordnance Finishes, Surface Roughness URAX6": "The finish specified represents the roughest surface acceptable regardless of method or material used. A finish finer than specified is ordinarily permissible without further authorization except when such results increased cost to the government, or when a particular characteristic of surface is required".

There are exceptions to this rule. In large turbine propulsion gears, for example, the roughing operation might have to be controlled in order to produce satisfactory surfaces in the end product. A relatively broad limit for surface roughness can be set for the preliminary operation.

This philosophy is well founded and finds an analogy in the gear art itself where oftentimes controls are established in a roughing operation merely to insure successful completion of the final operation. Such a parallel would be in the roughing of gear teeth prior to shaving or grinding. It is customary to give tooth thickness tolerance in the roughing operation merely to safeguard the end product. Such tolerances are usually liberal. In a similar manner a roughing operation could, under most conditions, have a relatively liberal surface roughness tolerance.

Since the specification of surface roughness of gear must receive special consideration, a special symbol is used to designate the quality of surface desired. This symbol should be different from any other used for a similar purpose and should bear a relation to gear tooth profiles. Fig. 7 shows a suggested symbol. This symbol focuses the attention to a gear tooth and not to some other portion of the gear, such as a hub, faces, bearings, etc. The letter and number inscribed within the tooth profiles designate the method of production and grade of surface desired.

Color Perception

One of the things that requires more study in evaluating surface roughness by means of visual comparisons is color perception. This matter has been given some study by investigators. The human eye is sensitive to color changes and quite frequently errs. The limitations of the human eye in making exact comparisons of surfaces, because of differences in color, is just as disturbing in evaluating the roughness of gear teeth as in examining other machine parts.

A hobbed bronze worm gear, for instance, has an entirely different color than a cast iron or steel gear. The cutter marks in the bronze material cause a prismatic effect, which is disturbing to the eye and frequently results in an incorrect evaluation. To determine the seriousness of this disturbance a number of gears of different materials were cut in a stack under the same conditions. Care was taken to have materials of approximately the same machinability but of different color. First, the gears were cut in individual stacks and then mixed up in the same stack. In all samples the conditions were the same including the keenness of the cutter. In endavoring to determine the visual difference in surface roughness between the gears of different material, the sense of color perception caused individuals to evalute the surfaces differently. Although the differences were small, and for all practical purposes might have been discounted, they nevertheless indicated a disturbance.

The next thing that was done was to gold plate all the gears by hanging them in a bath so that only a portion of the gears was plated. Gold was used since it has good plating properties, was available, and above all could be plated with an extremely thin coating without an undercoating. A fraction of a tenth of a thousandth was sufficient to reduce all of the gears to the same common denominator of color perception. When this was done, unanimous agreement was obtained on the quality of the surfaces of the different gears. It is not suggested, of course, that in order to eliminate the factor of color perception that gears or other machine parts must be gold plated. This experiment merely indicates that further studies on the subject are in order. Possibly the solution may be found in suitable color filters or in dusting compounds used in photography to reduce the light reflecting properties of shiny objects.

This whole subject of surface roughness of gear teeth is being given considerable study at present. Gear manufacturers are alive to need of suitable controls. Out of the many ideas advanced and the many things tried to reduce the determination of the gear tooth surface, best suited for a given application, to an exact unit of measurement, it is believed by many that something along the lines suggested by the author may be the answer. While it may not fulfill all of the expectations of the idealist, it will quite probably meet adequately the requirements of the man in the shop for which the standard is primarily intended.

Germans Used Inferior Alloys in Tools

GERMAN precision cutting tools and gages were inferior to American products during the war as a result of the use of less tungsten in alloy steel, according to a report on 13 German tool plants, released by the Office of the Publication Board, Department of Commerce.

Because of wartime shortages, the Germans progressively decreased the tungsten content in high speed tool steel from more than 12 percent in 1938 to 1½ percent or less in 1944. The composition in general use in 1944 consisted of carbon (0.92-0.98 percent), chromium (3.50-4.00 percent), vanadium (2.70-3.00 percent), tungsten (1.20-1.50 percent), and molybdenum (2.20-2.50 percent). A small amount of titanium was added in some mills.

Some German manufacturers stated that, properly ground and hardened, this low alloy steel ("Drierstahl") gave satisfactory results. Others said that the low red hardness of the steel necessitated a 35 percent reduction in tool speed.

ENGINEERING ABSTRACTS

FOREIGN AND DOMESTIC ARTICLES

Low-Pressure Laminates

From "Low Pressure Molding of Laminates" by J. E. Stokes, Bakelite Corporation. Presented Feb. 7, 1946 at the Canadian Section meeting, Society of the Plastics Industry.

LOW PRESSURE MOLDING is the technique of forming flat, simple, or compound-curved surfaces, from resin treated materials capable of permanent deformation, by means of applying heat and pressure. The pressures generally run below 500 lb. per sq. in. with particular emphasis on pressures from 250 down to 10 lb. per sq. in. Low pressure molding could also be described as a means of distributing a relatively uniform pressure over a prearranged resin bearing, fibrous assembly of cellulose, glass, or asbestos, with the application of heat from some external source, to form a cohered laminated structure, possessing definite physical properties.

Two types of thermosetting resins are generally used in low pressure molding; phenol formaldehyde and ester type resins. Phenolic resins may be used with any type of filler, while the thermosetting ester types are not generally used in an all-paper low pressure laminate. All of the strength properties of molded laminates are dependent upon both the resin and the filler. The time, temperature, and pressure applied during the curing cycle, are variable factors, and if any are changed, results will vary even when the same resin and filler are used. Some thermosetting resins, when used to produce glass-cloth laminates, produce excellent results. On the other hand, excellent strength results have been obtained on cotton base laminates with certain resins, and when the same resins were applied to fiberglas, poor bending strengths and other undesirable properties were obtained.

The bulk factor, or density of the filler, influences to some extent the minimum pressure which may be employed. In general, increased bulk means increased resin content, to effect flow at any given low molding pressure. Low resin content, high density papers, or tightly woven fabrics, mold at lower presures than water-leaf type paper or loosely woven fabrics, although materials having a low density are likely to spread better and fill out the contours of the mold. This is especially true when molding complicated shapes.

In treating materials, such as fabric or paper for laminating, the resin is allowed to penetrate, or is forced into the sheet, either by squeeze rolls or immersion of the sheet in the resin bath.

The equipment in which laminates can be molded at low pressure varies as widely as the pressures that can be used. A common method is the toggle operated hat press. One section of the mold is made from cast metal. The opposing section is a rubber bag incorporated in the head of the press. The resin-treated material—paper, glass or cotton fabric—is die cut and placed in a pattern over the metal mold. The toggle press is then closed and locked in place. Pressures varying from 50 to 250 lb. per sq. in. can be applied on the build-up by "bleeding" water into the rubber bag through the press head. Either a hand pump or high pressure water from a booster system may be used to develop this pressure. Heat is applied through the metal section of the mold, either by direct gas flame on the mold, strip heaters, or cored steam chests.

A second method of molding by low pressure is conventional hydraulic press, or a large plywood press. Indications are that the following properties may be improved in flat sheet laminates by useing reduced molding pressures: First, less warpage in the finished sheet. The filler material is subjected to less strains under low pressure, therefore, the fibers have less tendency to relieve themselves when the pressure is released; second, improved toughness. This is especially true when fiber glass cloth is used as a filler material. Higher pressures tend to crush the fibers of the base material, thus reducing its effectiveness; third, closer tolerances in thickness may be obtained. This is primarily because of less platen deflection, which is closely allied to the pressure exerted on the platen by the press ram.

Aircraft flooring, which utilizes the application of laminates on either side of a low density core material, each as balsa wood can be produced in one pressing operation only by low pressure. Such structures are light in weight, strong and wear resistant. From such constructions the entire floor assembly of the Waco C-G-4 glider was produced.

A new development worthy of consideration by plywood manufacturers is being used to produce economical decorative panels molded at low pressure. Special grades of paper are necessary, and the cost of the equipment required for processing this panel is low. Press plates of stainless steel or chrome plate, are sprayed with a special thermosetting resin to insure a covering of six to ten mils in thickness. Immediately following spraying, the plates are placed in an oven, or passed over a bank of infra-red lamps, during which the resin precures on the plate in four to ten minutes, to a point where the film is just dry to touch while still hot. This drying cycle is not critical. Veneers that have been glue spread can be assembled for hot pressing, however, it is advisable to place a minimum of three ply of 8 mil paper, impregnated with a phenolic resin, over the top and bottom surfaces to keep down the grain rise of the woods. The treated paper also acts as a binder and a base for transferring the resin on the sprayed plate, which is placed on top of the lay-up. The entire assembly is cured on the short cycle used in conjunction with the manufacture of heat bonded plywood, and the pressure applied is also the same—170 to 250 lb. per sq. in. The cured assembly may be discharged hot.

Another low-pressure laminating method employs an autoclave. A prearranged pattern of treated stock is placed upon a mold, and the entire assembly inclosed in a rubber bag, to which a vacuum line is attached. The bag is sealed and a vacuum drawn on the entire assembly, which gives an atmospheric pressure on the treated resin-bearing build-up. This rubber bag structure is then placed in the pressure chamber and the door closed to seal effectively the autoclave. Saturated steam is bled into the autoclave until a pressure of 60 lb. is obtained. This accomplishes a dual purpose. It supplies the heat necessary to polymerize the resin; and it applies additional pressure to the part being molded. If higher pressure is needed, air may be used with the steam.

Molds for autoclave work can be satisfactorily made from wood, metal-faced wood, cast metal, heavy gage sheet metal and plaster. Because of the impossiblity of charging a hot mold, and considering the mechanical adjustments necessary, such

as securing the door, and bleeding the steam into and out from the autoclave, the overall curing cycle could be considered a bit longer in this method. Because of the size of the autoclave usually used in commercial production, extremely large objects can be molded, or a great number of small objects can be produced in one cycle. Either a male or female mold can be employed in this method of low pressure molding, but as in all methods where the rubber bag acts as one part of the mold, only one surface of the finished laminate can be expected to have a smooth surface —the one adjacent to the hard molding surface.

A method of manufacturing curved products is the techniques of "post-forming" the piece from flat sheet laminates. Because of the necessity of using special phenolic varnishes, and pressures of approximately 800 lb. per sq. in. during the curing cycle, the flat sheet laminates are generally made on a high pressure laminator. The laminate is then cut to a predetermined size and preheated for 30 seconds to 3 minutes at temperatures from 350 to 500 deg. F. As a general rule higher temperatures are used with a short time cycle.

Immediately following the preheat cycle, the flat laminate is placed over a male or female die, or combination of both. Pressure is applied to an opposite die by means of compressed air, or a simple hand toggle press. The drawn or curved laminate cools to shape in the press, during the preheat cycle of the next laminate. The dies are usually fabricated from wood, heavy laminates, or metal. This permits a profitable production of a small number of pieces at a low cost.

The post-formed laminate can be stretched as high as 18.8 percent. Bending can be accomplished in a radius equal to the thickness of the laminate. All tests to date indicate that the properties of the post-formed laminate are equal to, or greater than the original laminate in tensile, flexural and water absorption.

Aluminum and Magnesium in Hoisting Equipment

Foreign Abstract condensed from "Light Metals in Hoisting Equipment" by A. G. Arend, *Mechanical World and Engineering Record*, May 10, 1946.

Cranes, hoists and similar equipment are likely to weigh less in the future because quantities of the light metals are now available and the use of them has several advantages. Where ground is relatively loose, hoisting is partly restricted to light weights for fear of subsidence. These conditions are considerably aggravated when the crane itself is unnecessarily heavy since it is a major cause of weight.

The aluminum alloys consisting of aluminum and 7 percent magnesium, often referred to as the sea-water alloys, have good corrosion resistance. These alloys are suited especially for dock and harbor cranes where corrosion resistance is needed.

Where hoisting arrangements are demanded on short notice at odd sites, cranes that weigh less can be operated at lower cost. Where equipment has to be set up at remote locations, time and labor are saved and transportation charges are lower. In short, the lighter crane is more economical in all respects with the exception of the initial cost.

Comparative weights of sections of two cranes, one of conventional steel design and the other of light alloys, are as follows:

	Steel, lb.	Light Alloy, lb.
Lift or hoisting sections..	3,318	1,592
Driving outfit	1,124	807
Main carrying layout.....	4,572	1,643
Electrical equipment	2,310	2,310
	11,324	6,352

No part of the electrical equipment was made of aluminum. All wheels, gears and shafts were made of familiar steels and gunmetal compositions. This was done because there was no point in gaining lightness at the expense of power. Neither was there any use in reducing the weight of grab buckets for use on material such as coal where weight is necessary to cause the bucket to function properly.

Reductions in weight can be made chiefly in the lift or hoisting sections and the secondary structure members as indicated in the foregoing tabulation. It is usually conceded that for large drydocks, the most suitable hoisting appliances are travelling slewing cranes with the base gantry-shaped so that working operations do not disturb other traffic at the docks. Many parts on such cranes as the craneman's cabin and trolley are undeniably heavier than necessary and can be replaced with the lighter alloys.

Cold-Forged Inserts

From "Cold-Forged Inserts" by William G. Waltermire in *Fasteners*, Vol. 3, No. 3, 1946.

THE INCREASED holding power and resistance to turning, and lowered cost of cold-forged inserts are becoming increasingly important to those who use metal inserts in die castings, plastic parts, and rubber moldings. Better cold-forged male inserts can be made at much lower cost than machined inserts but the fact that production is many times faster further multiples the value of this process to the user.

The only waste in the process of cold-forging is the minute amount lost in the coil ends. The companion process of cold-rolling the threads is likewise highly accurate, produces no waste, and is very fast. Fig. 1 points out the advantages of producing a standard screw machine insert design by cold-heading. If the material is to be of steel, a carbon steel is preferred to a free-cutting steel as the former is more malleable and will stand a greater range of cold-working. The numbered arrows on Fig. 1 are explained in the following paragraphs as advantages accruing to the user of cold-forged inserts.

1. The larger the collar diameter of the machined inserts the more metal and time will be wasted in turning down the ends. On the other hand, larger collars can be economically used if the insert is cold-headed because no waste is produced.
2. Cut threads require 2½ complete threads, as chasers cannot cut up to the shoulder. But rolled threads can be rolled within 1½ threads.
3. Points of machined inserts must be chamfered so that die heads can pass over them. Chamfer is not required for rolled threads.
4. Machined inserts must be symmetrical and concentric for best machining practice. Therefore knurling is the most practical way to prevent a machined insert from turning. But flat wings and ovals may be used in cold-forged inserts and these have far more resistance to turning.
5. Since the knurl of a machined insert is shallow as compared to the knurl rolled by thread rollers, the length of the knurled section of the machined insert must be longer to provide equal resistance to turning and equal holding.

In Fig. 2 are shown plastic inserts made by Lamson & Sessions and the Central Screw Co., and reproduced with the permission of the Society of the Plastics Industry. Note the following: Part 2—Fins under the head increase resistance to turning. Part 5—The hex shape under the head, combined with the round collar, provide resistance to torque and tension. Note also the 90 deg. indent that is put in as part of the heading operation. Part 7—This shape would be expensive to form on a machine. Note also the cross on the head. Part 8—Like indent and hex in Part 5, the flat on Part 8 is produced in the heading operation alone. Part 10—here the ratio of the large head to the small shank is great. This was obtained with no loss of material and no lengthy machining time.

Cold-heading design greatly widens the range and grades of brass, copper, alu-

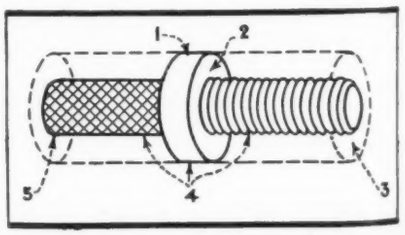


Fig. 1—Arrows point out advantages of cold-heading for making inserts.

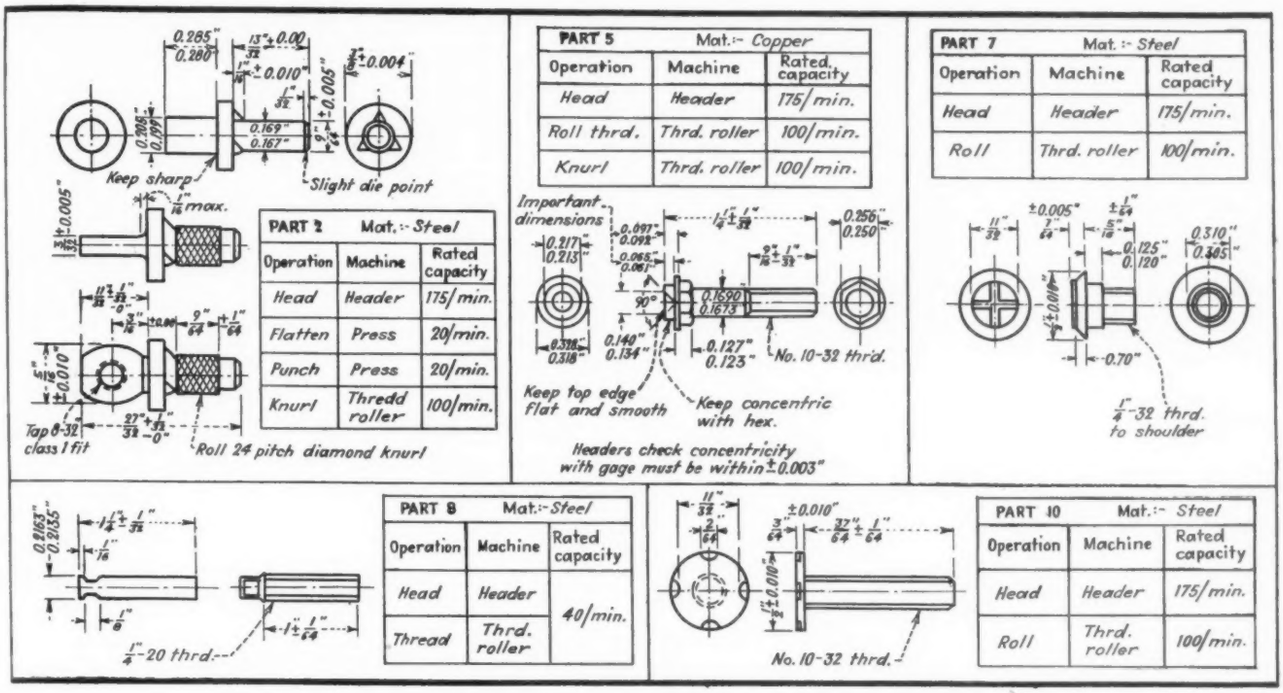

PART 2 Mat.:- Steel
Operation | Machine | Rated capacity
Head | Header | 175/min.
Flatten | Press | 20/min.
Punch | Press | 20/min.
Knurl | Thredd roller | 100/min.
Keep sharp
Slight die point
Roll 24 pitch diamond knurl
PART 5 Mat.:- Copper
Operation | Machine | Rated capacity
Head | Header | 175/min.
Roll thrd. | Thrd. roller | 100/min.
Knurl | Thrd. roller | 100/min.
Important dimensions
Keep top edge flat and smooth
Keep concentric with hex.
No. 10-32 thrd.
Headers check concentricity with gage must be within ±0.003"
PART 7 Mat.:- Steel
Operation | Machine | Rated capacity
Head | Header | 175/min.
Roll | Thrd. roller | 100/min.
1/4-32 thrd. to shoulder
PART 8 Mat.:- Steel
Operation | Machine | Rated capacity
Head | Header | 40/min.
Thread | Thrd. roller
1/4-20 thrd.
PART 10 Mat.:- Steel
Operation | Machine | Rated capacity
Head | Header | 175/min.
Roll | Thrd. roller | 100/min.
No. 10-32 thrd.

Fig. 2—Detail drawings of 5 different types of inserts showing manufacturing operations.

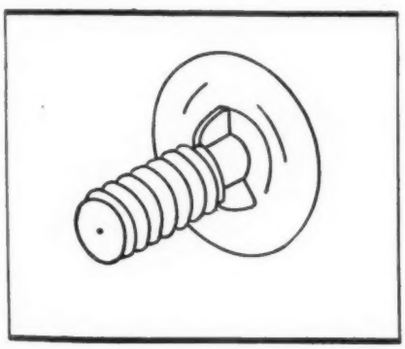


Fig. 3—Cold-headed insert.

minum and steel materials that can be used to satisfy the requirements of a particular insert such as electrical conductivity and resistance to corrosion. Fig. 3 shows the design that achieves high anchorage in a very short length and still costs much less than a conventional machined insert. The flat neck and wings are set in the molded material, the nut prevents turning and acts in conjunction with the the large flat head to prevent axial movement. This achieves high anchorage in a short length with low cost. And furthermore the problem of cleaning the inserts, which would be necessary with a knurled design, is simplified.

Cold-forging has some disadvantages. It is not applicable to female inserts, which are better machined since the necessary drilling and tapping can be done in the first operation. The use of an annular groove around the middle of an insert is not recommended. Anchorage can be obtained by changing the design, and if the screw were included it might increase the cost of cold-forged parts.

Cold-forging easily meets the normal requirements for insert tolerances.

Length—Plus or minus 0.010 in.
Fillets—Sharp or round as specified
Diameter—0.002 in. minimum
Squareness, shoulders or collars with shank—Plus or minus 1 deg. maximum

The production volume required for economical adoption of cold-heading is not as large as is generally believed. Consideration should be given to cold-forging if the quantities to be produced are as low as 50,000. To take full advantage of the possible savings and better holding power of cold-forged *inserts, plastic designers should settle the following questions:

1. If the existing shape, proportions and dimensions must be maintained, should the material and tolerances specified be those that are most economical for headability, or best for machinability? Shall alternates be provided to care for both conditions?
2. Can the insert be improved by changing its shape and proportions to provide more anchorage at the same or decreased cost?
3. Will such an insert be easy to load and come free easily when the part is knocked out of the mold? Will it be crushed or distorted or come loose in molding?

When satisfactory answers are developed for these basic questions, the designer can determine dimensional details with full confidence that he has achieved maximum utility with minimum cost.

Self-Healing Capacitor

From report on "Manufacture of Metalized Paper Fixed Capacitor Units by the Robert Bosch Co., Stuttgart, Germany," by Fred E. Henderson, July 16, 1945, Member U. S. Technical Industrial Intelligence Committee. Refer also to U. S. Pat. 2,244,090 in custody of Alien Property Custodian, Washington, D. C.

A SELF-HEALING metalized paper type capacitor that is much more compact than American types was developed by Germany during the war. Bosch produced 40 million such units for both a.c. and d.c. applications. It is estimated that to manufacture them the design and production of the special machines would cost $25,000 but these fixed paper capacitors would be 40 percent smaller than present paper and foil types and could be produced for 20 percent less cost.

The salient features of the construction are: An extremely thin film of bakelite varnish is applied to one side of the paper, following which zinc vapor is applied in a vacuum. The thickness of the zinc film on the paper is about 2 microns. Consequently, should a voltage break-down occur, because of a pin hole or weak spot in the dielectric, the extremely thin film of zinc acts as a fuse and the capacitor prac-

tically always "burns open" instead of a short-circuiting, as is the case with the conventional rolled paper, metal foil, capacitor.

The metalized paper condenser heals automatically after an electrical breakdown occurs because the very thin metal film completely evaporates around the point of breakdown so that an adequate insulating margin is established. Thus innumerable breakdowns can occur before the effective area of the condenser plates has been reduced to the point where they will no longer produce satisfactory capacity values. Therefore metalized paper capacitors are operated at 20 to 50 percent higher voltage than is possible with metal and foil capacitors.

The metalized paper condenser uses kraft paper 0.0003 in. thick as the dielectric upon which the metal coating is vaporized. The quality of the paper is controlled by applying a 500 volt breakdown test to all of the paper used. This is done by passing the paper between two moving foil electrodes. The paper travels between the electrodes at the same speed as the electrodes so that the entire surface is exposed to the breakdown voltage for a period of about three seconds. This test set is equipped with a counter so that the number of breakdowns that occur per unit area is a measure of the quality of the paper. This test also burns out any metallic or ionized particles and thus produce a better quality of paper for the condenser unit.

The kraft paper is varnished on one side in a special varnishing machine at a speed of one meter per second. In principle this machine is a rewinding machine that takes the roll of 360 mm. wide kraft paper and rerolls it on to another roll. This machine has a vaporizing oven that toughens the paper and tends to remove any static charges. This minimizes the tendency of the paper to curl up as it passes through the machine. Cellulose nitrate varnish is used.

The metal vaporizing machine is also in principle a rewinding machine except that all of the mechanism must be inclosed in a vacuum chamber capable of being evacuated to a pressure of 0.1 mm. of mercury. The speed of the paper through this machine is 6 meters per sec. so that it has to be a well designed machine from a mechanical standpoint. The zinc metal is melted in an electrically heated pot type furnace that has a special nozzle type opening in the top through which the zinc in vapor form passes directly onto the paper. This furnace is equipped with water-cooling coils for rapid control of the temperature.

This machine has two insulated metal rolls spaced at a distance of 25 mm. apart. The metalized surface of the paper is held in intimate contact with these two rolls as it passes through the machine. The two metal rolls are connected into one arm of a Wheatstone bridge so that the d.c. resistance of the metal coating between these two rolls can be observed continuously on the bridge galvanometer. This provides a means of determining the thickness of the metal coating continously. The speed of the takeup roll is controlled by means of a magnetic brake operated through a hand-controlled potentiometer. Thus the operator has three specific controls for obtaining the desired product: (1) The water-cooled coils on the zinc evaporating furnace gives rapid control of the temperature so that the quantity of zinc vapor generated by the furnace can be changed quickly; (2) the magnetic brake controls the speed of the paper as it passes over the nozzle of the vaporizing furnace; and (3) the Wheatstone bridge tells whether or not the desired thickness of coating is being obtained. The zinc coating is held to a thickness of 0.0001 mm. or less.

Post-Forming Laminates

From "Post-Forming Developments During the War and their Applications to Peacetime Products" by William I. Beach, Henry J. Kaiser Company. Presented Feb. 2, 1946, at the Low Pressure Conference, Society of the Plastics Industry.

ALTHOUGH POST-FORMING is categorically classified as low-pressure molding, it deviates from conventional methods, mainly in production technique. In practice, post-forming has much in common with many of the metal fabricating methods. As in metal forming, thermosetting laminated sheet stock is stretched and deformed by externally applied forces. Interchangeability of dies and tools from metal forming to plastic forming is frequently possible. However, it is seldom practical to do so in view of the novel and unique die arrangements devised especially for post-forming.

Post-forming is the direct outgrowth of the effort to expedite the production of airplanes. The necessity for replacement materials and ways of processing them led to the development of post-forming.

At the beginning even small parts having simple right angle bends in more than one direction introduced considerable problems. This was solved by the construction of the book die (Fig. 1), which is typical of the type of tooling used in the early stages of the forming development. For reasons of cost, ease of construction and particularly to expedite tooling, wood was the principal material employed in these dies. The fact that tooling could be made inexpensively and rapidly did much to encourage further interest in post-forming.

From the conventional bending dies, the next step in tool design led to the forming of simple compound bends and curves. The lamp bracket shown in Fig. 2 is representative of the caliber of work demanded for production. The plunger type die shown in this photograph is one of the first to incorporate both hand and press operation. The force plug was attached to the ram of an arbor press. The sides were pushed up by hand and clamped in place with ordinary C-clamps. Eventually, this work was accomplished automatically and in less time through the use of pneumatic presses. Cams were devised to press the sides together when the plunger forced the spring loaded die downward to a stationary base. A plastic dome light bracket shown beside the die denotes beads and angles drawn and formed in one and the same operation.

Later, with advancement in both forming technique and production tooling, more complicated parts were possible. After wood had served well in experimental and temporary dies, more permanent ones consisting of Kirksite, Masonite, aluminum, laminated and cast plastics or a combination of several of these materials were found more durable and required less maintenance. Furthermore, with two and three-stage dies designed to function automatically with air presses, some parts could be formed faster and at lower cost than comparable metal ones made with conventional metal work equipment. Several such parts are seen in Figs. 3 and 4. These represent parts of a console assem-

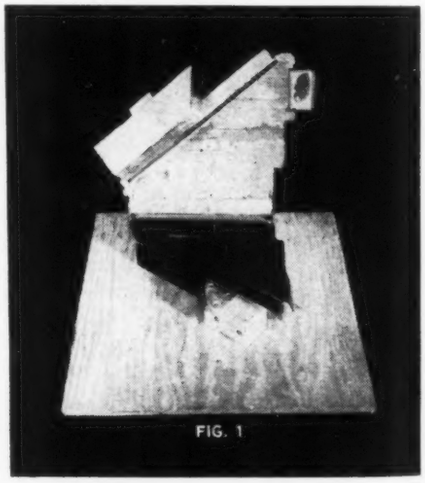


FIG. 1

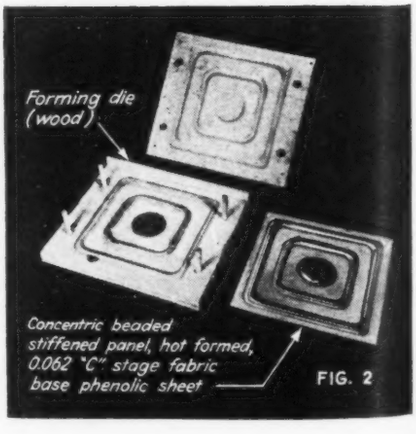


FIG. 2

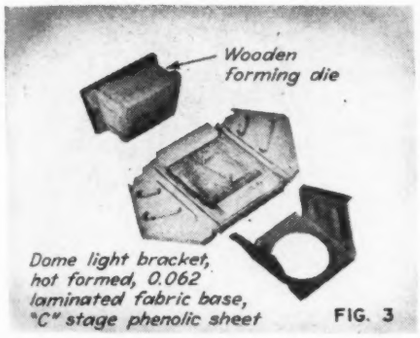


FIG. 3

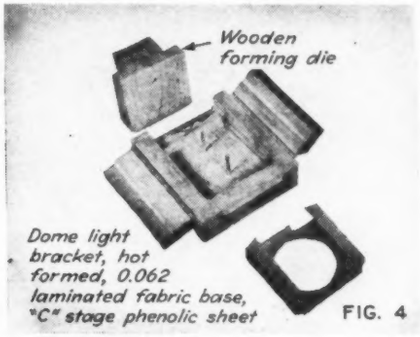


FIG. 4

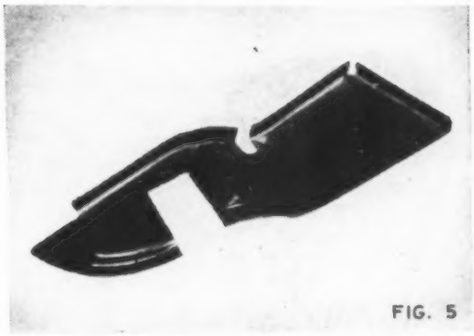


FIG. 5

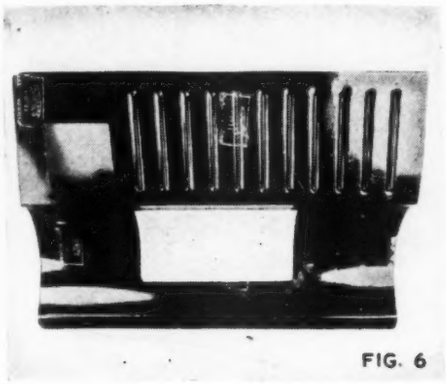


FIG. 6

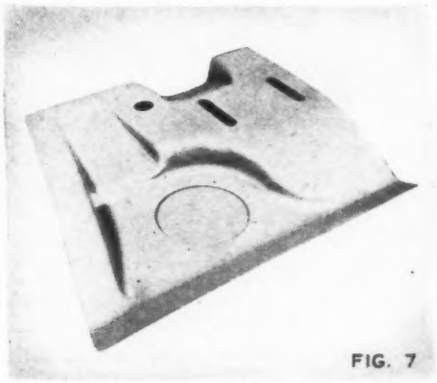


FIG. 7

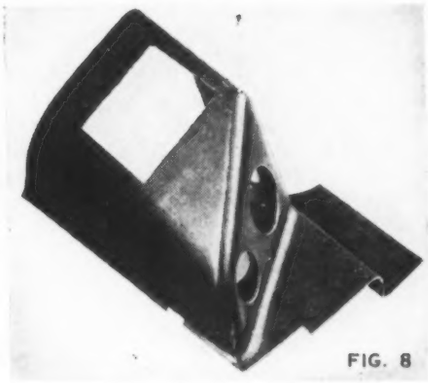


FIG. 8

bly found in the cockpit of one of the latest military airplanes. The complete assembly consisting of more than fifteen individual components provides support for various instruments and tough, resilient panels for the walls.

In addition to the optimum reduction of cost and weight expected of formed laminated items other benefits are derived; namely, electrical and thermal insulation, resistance to abrasion and corrosion and reduction of motor noise transmission. In Fig. 5 is shown another console part along with the forming die. The two base plates are fabric base laminated phenolic sheets. Upon the lower matching plates, made of cast phenolic plastic, rests the formed part. Directly above is the upper matching plate, which is also made of cast phenolic.

While improved technique and tooling were responsible for the forming of compound bends and curvatures, an equal amount of work was devoted to ways and means for obtaining deep drawn shapes. Figs. 6, 7 and 8 show three steps in the drawing of the upper ball turret housing used on a bomber airplane. In Fig. 6, the flat sheet or blank at 1/8 in. laminated material is held in place by the steel pressure plates. Above it, attached to the ram of an air cylinder, is a Kirksite ball punch. The lower socket portion of the mold is also made from Kirksite. Around the edges are fastened pressure cams that exert the necessary hold down pressure and prevent lateral wrinkles developed as the material draws from extending down into the cavity of the formed part. Another view of the formed ball turret removed from the mold is shown in Fig. 7. The size and shape is clearly defined in this view. In Fig. 8 is shown a direct comparison of a blank, drawn part, and the part trimmed to finished dimensions.

An ingenious item now being produced in considerable quantity is a deep freeze unit manufactured in Los Angeles, California. A formed plastic container, which is designed to accompany the sportsman on fishing or hunting trips, this freeze unit has ample capacity and refrigerating life to transport game or fish hundreds of miles at a temperature well under 0 deg. F. Oval in shape, the outside dimensions of the freezer are 24 x 18 x 18 in. The outside surface consists of formed laminated sheet material. All hardware is metal. Inside, spaced about two inches from the outer wall, is an aluminum container nested in a layer of fiberglas insulation. Attached to the top is a perforated box which holds standard dry ice bricks.

One of the most promising applications for post-formed plastics is in the decorative field. Prior to World War II, decorative sheet was usually restricted to flat surfaces. Cove bases and flanges were attached by chromium plated joining strips. Installation costs, plus the fact that some of the most attracitve features of decorative patterns were frequently marred by attaching fixtures, was a disturbing factor.

With the advent of formed decorative laminates, a new and no doubt greater application of these materials is in the offing. Since most plastic decorative sheet materials are paper base laminates, considerable difficulty has been experienced in achieving the forming characteristics of woven fabric or mat filled laminates. However, right angle bends and slight draws may not be obtained. As a result of experimentation, one of the first items to be attempted was a sink tub. This is a unit in which the flat area, cove base and edge flanges have been formed from a single sheet of decorative laminate. A complete kitchen unit has been assembled recently in which the sink, drainboard, service tables and various wall sections are entirely covered with formed decorative laminates.

A process that has potential applications is the forming of low-pressure molded or laminated fiberglas reinforced plastics. Recent tests indicate comparable formability to that of the fabric base products. With this development, structural materials are now available for post-forming.

Design, Production and Research

Foreign Abstract condensed from "General Trends in Engineering Development" by A. S. Darling in *Mechanical World and Engineering Record*, Manchester, June 7, 1946.

DESIGN, production and research are the threefold activities of the engineer. Design involves two separate modes of thought: The first is analytical; the second is synthetic. The duties a particular machine is to perform are analyzed, separated and classified. Simplicity is the main criterion of worth, and the best design is that in which the basic elements of the machine have been reduced to a minimum consistent with efficient working.

The synthetic process involves the mental creation of devices to carry out these duties. Both analysis and synthesis, inseparable in many ways, have to be quantitative rather than qualitative, and thus arises the necessity for adequate mathematical ability. Production involves the working of materials to the form

specified by the design.

Research can be pure or applied. The pure research worker determines the fundamental laws; the applied worker uses them to produce a cheaper or better article. Many times in the past the practice of engineering has been far in advance of theory. Under such circumstances progress is necessarily haphazard and not likely to yield anything of great value.

Primitive objects for a given purpose, from widely separated parts of the world, reveal striking similarity. The evolution of design under primitate man was slow for two reasons: (a) An unconscious system of solution based on small variations of the original article; (b) improvement from the aesthetic sense of the craftsman. Primitive man is creative: He is usually proficient in the plastic arts, but in the production of tools he is guided by his aesthetic sense and has only the guiding hand of tradition behind him. A rational process of design requires not only a knowledge of mathematics but also an appreciation of the laws of nature.

Modern developments derived their impulse indirectly from the Greeks, who were the first to make notable advances in both mathematics and a study of the laws of nature, but who achieved little engineering progress because of the great gap between artisans and those who discovered the general laws. From 400 B.C. onward, the analytical ability of cultured man was well developed. Only the ignorance of basic physical laws retarded engineering development. Newton, by evolving a universal system of mechanics, placed in the hands of engineers their first and most essential tool.

All the general engineering trends that followed have had one great effect—the increase in working stresses and the reduction of the factors of safety on the materials used. This in turn has necessitated the designer being more accurately informed as to the mechanical properties of materials and thus his coordination with the metallurgist has grown increasingly obvious. Alloys for high temperature service are presently being investigated.

Involute Splines

From "Engineering of Involute Splines" by George L. McCain, in S.A.E. *Journal*, May, 1946, pages 245-260, published by The Society of Automotive Engineers, Inc.

IN THIS PAPER, presented at the SAE Annual Meeting, Detroit, Jan. 11, 1946, Mr. McCain discusses the engineering basis on which the Involute Splines Standard was formulated, setting forth the reasons why the standard should have widespread use by automotive and general mechanical equipment manufacturers, and suppliers of tools and gages.

In addition the author also presents the historical background of the project as a cooperative accomplishment with other groups, such as the national associations of the general mechanical, gear and tool industries.

Since multiple splines divide the load among a number of teeth, they are much shorter than an equivalent single key. If the load is to be divided equally, each spline may be designed to carry its share of the load, with two considerations: First, the fiber stress at the root of a tooth; and second, the tooth contact area. Either one may be the controlling factor, depending on operating requirements, but the torque capacity of either is limited by the capacity of the shaft on which the spline teeth are cut.

Torsional tests of plain splined shafts indicate that their strength is equivalent to that of a shaft of slightly less than the minor diameter. Failures were attributed to the sharp corners at the root of the spline. In the involute type of splined shaft, tests have shown it to have a strength equivalent to that of a shaft larger than the minor diameter, indicating that with he fillet, the spline teeth add strength under fatigue loading.

Sometimes the designer has complete control of the diameter of shaft to be used, but often has to accommodate a ball bearing or other fixed part supplied in predetermined sizes. With the old spline standard, there were sizes every 5 mm. step in diameter, and with the straight spline there were steps of $\frac{1}{8}$ in. from 0.750 in. dia. up. In the new standard proposed for involute splines, almost any diameter can be found in some diametral pitch.

The "E" Type Test Piece

Foreign Abstract condensed from a communication from the Technical Department of The Northern Aluminum Company Ltd., in *Metallurgia* (England) February 1946.

IN THE acceptance testing of sand castings of a high strength aluminum-magnesium alloy, containing 10 percent magnesium, used for highly stressed aircraft parts it was found that the standard type of separately cast test bar failed to produce results that could be correlated with the properties of the castings. Further investigations indicated that large variations in physical properties were obtained from different test bars cast from the same melt. Metallurgical investigations showed that the variations from bar to bar were caused by variations in the degree of segregation of the magnesium and that the degree of segregation was dependent on the speed with which the test bar was poured.

Several types of sand-cast test pieces with different heading and gating arrangements were investigated in an effort to develop a type in which the variations in pouring rate would not affect the properties of the test bar. These tests led to the development of the type "E" bar shown in Fig. 1. In this bar the "chokes" between the central feeding head and the test specimen proper regulate the feeding rate so that variations in the pouring rate at the feeding head have no effect on the test specimen.

Although the correlation between the physical properties of the test specimens and the castings made from the same melt is not very close, the type "E" specimen gives sufficiently uniform results to permit its use in product control work.

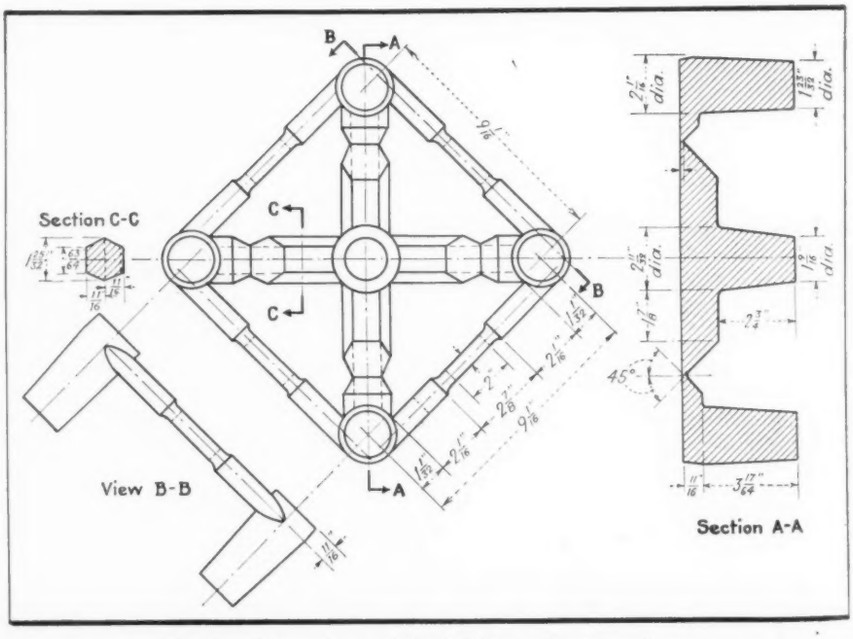


Fig. 1—Dimensions of the "E" type test specimen.

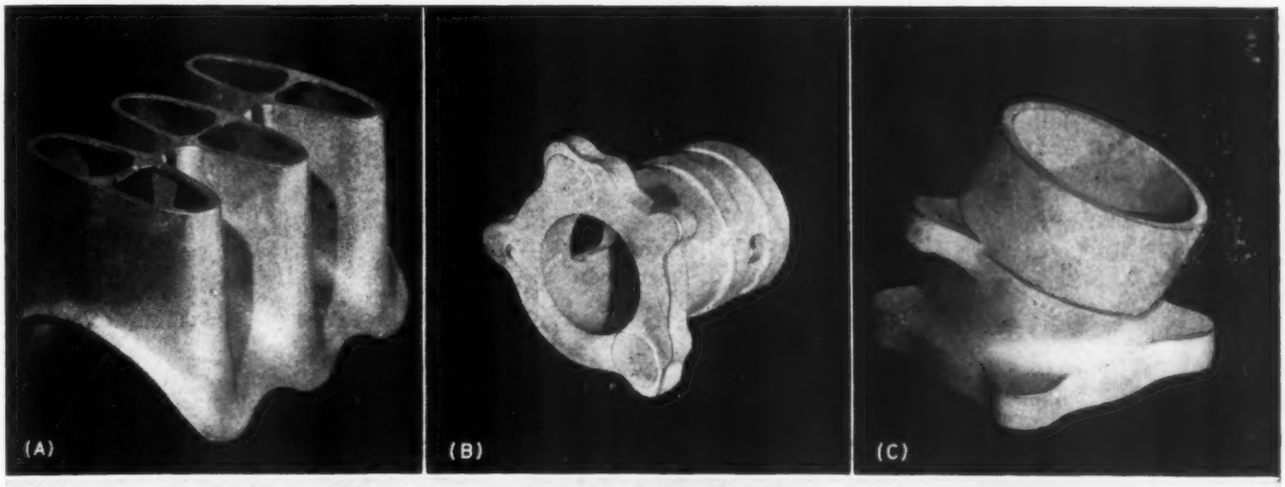


Fig. 1—(A) Jet outlet nozzle for operation at high temperatures. The part can be cast either from Hastelloy alloy C or from Haynes Stellite alloy No. 21; (B) An aircraft carburetor part, precision cast with eccentric flange thereby allowing the part to be finished in two simple machining operations; (C) Exhaust coupling for Pratt & Whitney, 3,200 hp. engine. This part is precision cast by gravity pouring of 18-8 stainless steel, stabilized with columbium.

Precision-Cast Parts Of High-Temperature Alloys

W. O. SWEENY
Haynes Stellite Company

Physical and mechanical properties, creep data and chemical composition of five alloys for high-temperature service. Design data are given dealing with tolerances on dimensions, weight and dimensional limitations on sizes of precision-cast parts and types of parts generally suited for manufacture by precision-casting methods.

PRECISION-CASTING-METHODS of shaping parts have contributed as much toward the economical application of high temperature alloys as the development of the alloys themselves, for the properties of many of these alloys are such that parts cannot be produced commercially from them by machining, forging and other conventional methods of fabrication. The development of the alloys was made possible only because the precision-casting method provided a means of adapting the materials to the desired shapes with a minimum of finishing operations. Any shape or form that can be machined or forged also can be made as a precision casting.

Among the alloys that have been developed for high temperature service are those known as Haynes Stellite alloys No. 21, 23, 27, 30 and 31. The properties of these alloys, until a few months ago classified as restricted data, are given here, together with information on how to use them in the design of precision-cast parts. Fig. 1 illustrates some precision castings, which appear much like castings made by other methods.

Turbosupercharger buckets, gas turbine blades, jet engine nozzles and vanes and even blades for high temperature steam turbines are typical parts made from the high temperature alloys. The P-80 Shooting Stars, which recently flew across the continent in a little over four hours were powered with I-40 engines having precision-cast turbine blades of No. 21 alloy, Fig. 2(A). Fig. 2(B) illustrates several designs of blades for locomotive propulsion.

One of the first production applications in high temperature service was the use of alloy No. 21, commonly called "Vitallium," in turbosupercharger buckets. Altogether some 40 million of these parts have been cast by the precision method. Initially these buckets were mechanically held. As the need for greater production of superchargers increased, the design of the base of the buckets was changed, first for hand welding and later for Unionmelt machine welding.

Changing airfoil sections with trailing edges as thin as 0.012 in. and shrouds form the vanes in the nozzle diaphragm of an aviation gas turbine, Fig. 3. Although millions of parts such as these have been made from alloy No. 21, recent trend in design has been toward parts made of

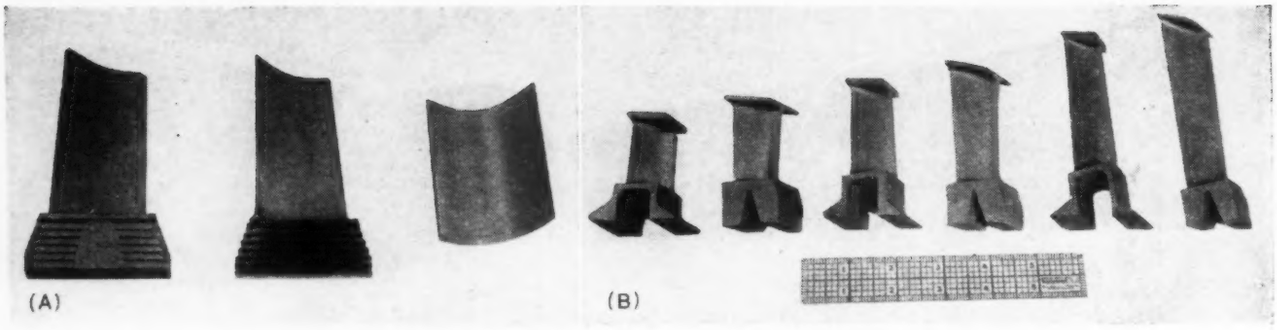


Fig. 2—Precision-cast turbine blades of Haynes Stellite alloy No. 21; Blades can be precision-cast in any desired size and with bases of any desired shape for mounting.

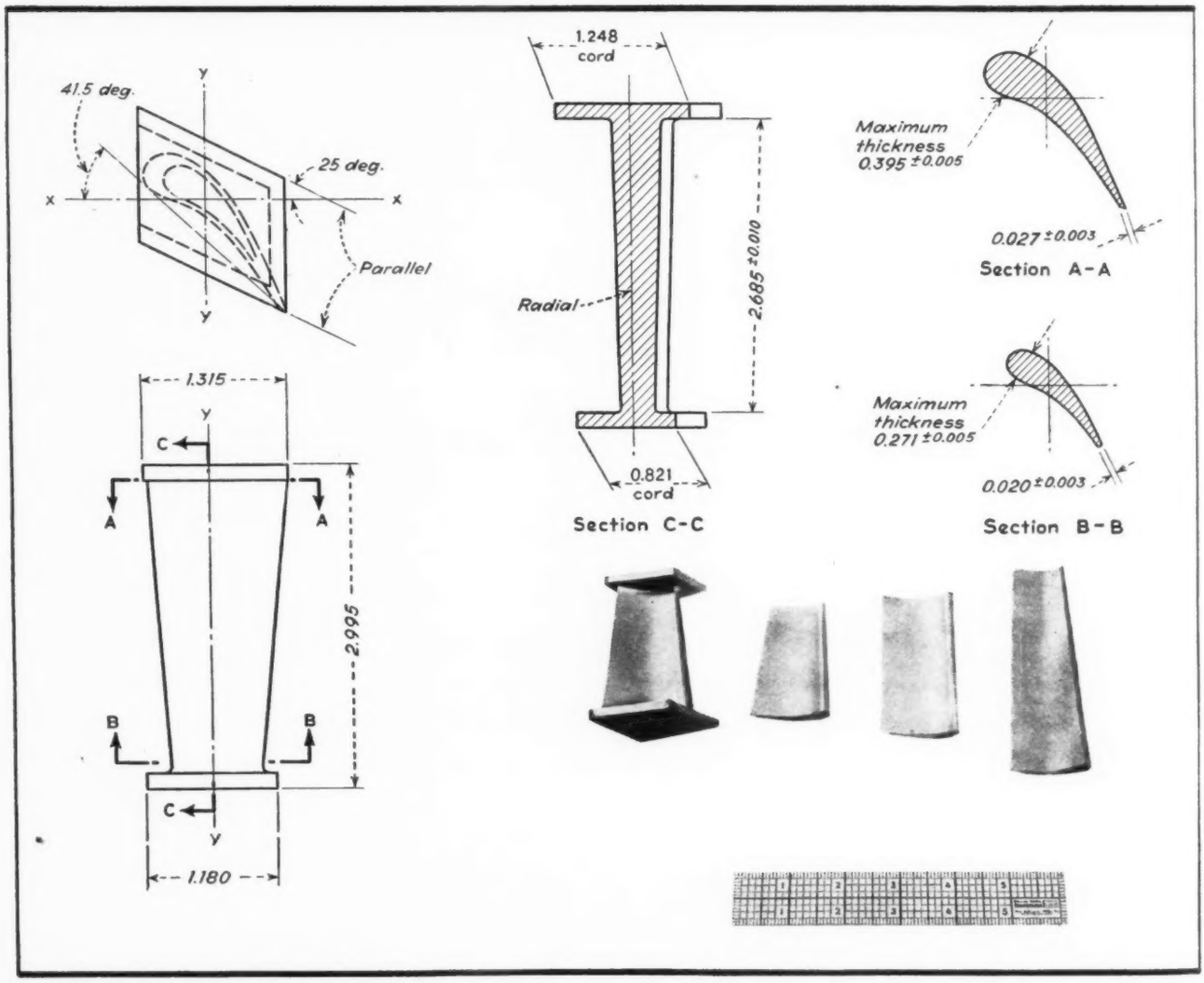


Fig. 3—Vanes of alloy No. 21 for use in the nozzle diaphragm of an aviation gas turbine.

alloys No. 30 and 31. All the alloys are suitable for use in places where corrosive gases at high temperatures impinge upon them. Relative strengths of the alloys at four temperatures are indicated by the curves of Fig. 4. Table I contains data on the tensile properties of the alloys at elevated temperatures. In using these data for design calculations and in specifying the material on drawings, allowance should be made for the difference between the condition of the alloy as installed and its condition as listed in the tabular data.

Creep-test data are given in Table II. These data are being used in design calculations in the absence of and until more extensive test data can be obtained. The deficiencies can be minimized if the data are prepared in the form of curves. Fig. 5 illustrates the way in which one group of the data have been charted in convenient form for use in design calculations.

Other data for design calculations are given in Table III. The age hardening data, Table IV, have an interesting origin. Early in the supercharger program, a cylinder failure on a test engine at Wright Field revealed, upon investigation, that the leading edges of the turbosupercharger buckets had aged excessively. The composition of

Table I—Short Time Tensile Properties.

Alloy No.	Test Temperature, deg. F.	Ultimate Tensile Strength, lb. per sq. in.	Yield Strength, lb. per sq. in.	Elongation in 2 in., percent	Reduction of Area, percent	Modulus of Elasticity, lb. per sq. in. in millions	Conditions of Test Alloy
21	Room	132,000	65,000	50.0	40.0		
	1,000	69,100	39,100	16.4	25.3	33.3	As cast
	1,000	86,200	74,400	1.2	4.3	35.	Aged 50 hr. at 1,350 deg. F.
	1,200	74,200	38,000	15.7	36.9	33.7	As cast
	1,200	89,300	71,300	2.0	6.0	23.9	Aged 50 hr. at 1,350 deg. F.
	1,350	79,300	61,500	3.8	9.0	24.2	" "
	1,500	59,000	49,000	6.8	19.7	16.8	" "
	1,600	41,600	32,800	19.3	23.6	15.4	" "
	1,700	42,500	.....	27.	52.4	....	As cast
	1,800	33,300	.....	35.	52.4	....	As cast
	1,800	32,900	.....	49.	63.1	....	Aged 16 hr. at 1,700 deg. F.
23	Room	105,400	58,400	7.0	11.2	....	As cast
	1,000	77,100	41,400	14.8	24.1	27.9	As cast
	1,000	97,500	72,500	1.7	4.1	27.6	Aged 50 hr. at 1,350 deg. F.
	1,200	82,900	40,700	15.6	21.5	33.5	As cast
	1,200	97,500	74,700	1.8	6.6	25.0	Aged 50 hr. at 1,350 deg. F.
	1,350	79,600	63,100	2.0	6.5	27.0	" "
	1,500	58,500	40,600	7.8	12.7	23.5	" "
	1,600	45,800	33,100	9.8	16.8	21.9	" "
	1,700	37,500	.....	7.	35.7	....	As cast
	1,700	43,600	.....	18.	35.7	....	Aged 16 hr. at 1,700 deg. F
	1,800	33,100	.....	32.	40.6	....	As cast
	1,800	33,000	.....	27.	39.5	....	Aged 16 hr. at 1,700 deg. F.
27	Room	82,500	46,900	7.	10.3	....	As cast
	1,000	50,500	36,600	4.3	10.3	26.2	As cast
	1,200	48,900	35,000	3.8	8.0	27.0	As cast
	1,350	66,200	50,800	3.2	4.6	20.2	Aged 50 hr. at 1,350 deg. F.
	1,500	51,200	38,200	10.1	14.4	18.7	" "
	1,600	41,400	30,800	11.5	20.1	18.2	" "
	1,700	43,000	.....	23.0	26.5	....	As cast
	1,700	45,400	.....	16.0	34.0	....	Aged 16 hr. at 1,700 deg. F.
	1,800	33,400	.....	24.0	50.3	....	As cast
	1,800	33,700	.....	26.0	41.7	....	Aged 16 hr. at 1,700 deg. F
30	Room	98,100	55,100	5.0	11.9	....	As cast
	1,000	62,900	42,500	6.2	9.2	25.6	As cast
	1,200	59,900	37,600	6.3	10.7	27.5	As cast
	1,350	77,800	61,400	1.8	2.7	24.8	Aged 50 hr. at 1,350 deg. F.
	1,500	64,000	47,600	3.0	3.4	25.6	" "
	1,600	48,900	35,900	9.6	17.8	17.3	" "
	1,700	45,200	.....	17.0	26.6	....	As cast
	1,700	47,100	.....	18.0	33.3	....	Aged 16 hr. at 1,700 deg. F.
	1,800	36,300	.....	24.0	33.7	....	As cast
	1,800	37,800	.....	21.0	38.7	....	Aged 16 hr. at 1,700 deg. F.
31	Room	101,000	74,100	11.0	14.0	....	As cast
	1,000	80,100	40,200	20.0	33.5	33.5	As cast
	1,200	77,000	37,600	19.0	28.4	22.8	As cast
	1,350	75,700	53,600	4.6	7.6	23.9	Aged 50 hr. at 1,350 deg. F
	1,500	59,600	44,500	10.3	14.1	19.3	" "
	1,600	48,600	36,200	14.3	18.1	19.0	" "

alloy No. 21 was immediately altered. Thereafter on each heat of metal a control specimen was aged for 50 hr. at 1,475 deg. F. to make sure the alloy would not overage in service. This is regular procedure now for all cast high-temperature alloys.

The compositions of some Haynes high temperature alloys are indicated in Table V. Hastelloy alloy B and Multimet alloy, other products of the Haynes Stellite Company that are often used in high temperature service, are forging alloys. At the lower temperatures or for short periods of service at higher temperatures the superiority of the cast alloys over the forged materials is frequently inconsequential, but for increasing temperatures and long exposure to high temperatures the cast materials definitely show superior qualities.

All five of the cast alloys described here represent compromises between physical properties at elevated temperatures and ease of shop handling, including machinability, weldability and ductility at room and high temperatures. They are commercially practicable so long as precision-casting methods can be used to get parts of the required shape. Accordingly, the design of parts should be adapted to precision casting.

The first step in the manufacture of a

Table II—Creep Test Data

Alloy No.	Temperature, deg. F.	Stress, lb. per sq. in.	Duration, hr.	Deformation Under Applied Load	Creep Rate, percent per hr. at 500 hr.	1,000 hr.	1,500 hr.	2,000 hr.	Total Deformation, percent at 500 hr.	1,000 hr.	1,500 hr.	2,000 hr.
21	1,350	15,000	2,106	0.068	0.0003	0.00019	0.00007	0.0001	0.442	0.540	0.596	0.662
21	1,350	12,000	1,800	0.069	0.00013	0.0001	0.00008	0.00008 (a)	0.220	0.275	0.318	0.338 (a)
23	1,350	20,000	1,300	0.068	0.00036	0.00042	0.00063 (b)		0.292	0.518	0.712 (b)	
23	1,350	15,000	1,560	0.050	0.00025	0.00016	0.00014		0.234	0.310	0.379	
27	1,350	20,000	1,536	0.070	0.00045	0.00047	0.00047		0.446	0.690	0.950	
27	1,350	15,000	1,656	0.076	0.00044	0.00008	0.00008	0.00004 (c)	0.405	0.479	0.519	0.533 (c)
27	1,350	12,000	2,348	0.042	0.000005	0.000002	0.000002	0.000002	0.135	0.137	0.140	0.140
30	1,350	15,000	....	0.075	0.00015	0.00007	0.00004	0.00003	0.262	0.320	0.342	0.360
30	1,350	15,000	2,160	0.062	0.000184	0.000119	0.000073	0.000062	0.267	0.363	0.408	0.438
(a) When discontinued at 1,800 hr. (b) Data for 1,300 hr. (c) When discontinued at 1,656 hr.												
21	1,500	7,000	2,002	0.036	0.0001	0.000205	0.00011	0.00009	0.127	0.208	0.296	0.344
21	1,500	7,000	2,086	0.046	0.000224	0.0001	0.00006	0.000065	0.285	0.354	0.405	0.439
21	1,500	7,000	2,015	0.039	0.00027	0.00014	0.000135	0.0001	0.215	0.348	0.417	0.500
23	1,500	12,000	2,780	0.080	0.000285	0.00011	0.000085	0.000085 (g)	0.506	0.608	0.657	0.682 (g)
23	1,500	12,000	2,136	0.035	0.000022	0.000062	0.000024	0.000024	0.176	0.201	0.205	0.222
27	1,500	12,000	1,778	0.078	0.00019	0.00018	0.000080	0.00008 (i)	0.305	0.500	0.575	0.600 (i)
27	1,500	12,000	2,039	0.075	0.00041	0.000198	0.000132	0.00013	0.678	0.815	0.894	0.963
30	1,500	12,000	1,997	0.069	0.00021	0.000068	0.000035	0.000035	0.430	0.487	0.507	0.523
30	1,500	12,000	2,082	0.060	0.000191	0.000079	0.000061	0.000046	0.397	0.453	0.489	0.524
(g) When discontinued at 2,780 hr., rate was 0.000023 percent per hr., total deformation was 0.70 percent. (i) When discontinued at 1,778 hr.												
21	1,600	10,000	2,065	0.120	0.00033	0.00013	0.00013	0.00013	0.790	0.900	0.980	1.036
21	1,600	7,000	2,184	0.089	0.000125	0.000044	0.000044	0.000044	0.258	0.308	0.330	0.353
21	1,600	5,500	1,488	0.063	0.000036	0.000031	0.000031		0.122	0.130	0.163	
23	1,600	9,000	833	0.058	0.0002	0.0001 (d)			0.300	0.332 (d)		
23	1,600	7,000	1,536	0.024	0.00005	0.000036	0.000036		0.173	0.193	0.207	
23	1,600	5,500	2,184	0.035	0.000045	0.000025	0.000025	0.000025 (e)	0.105	0.127	0.152	
27	1,600	11,000	2,059	0.060	0.00036	0.00031	0.00026	0.00025	0.627	0.784	0.922	1.05
27	1,600	9,000	2,070	0.050	0.00002	0.000013	0.00001	0.00001	0.143	0.153	0.162	0.165
27	1,600	7,000	2,187	0.045	0.00005	0.00003	0.00002	0.00001	0.141	0.158	0.169	0.171
30	1,600	12,000	2,035	0.080	0.00027	0.00023	0.00011	0.00028	0.700	0.815	0.880	0.980
30	1,600	11,000	2,250	0.051	0.000085	0.00002	0.00002	0.00002	0.284	0.301	0.313	0.325
30	1,600	9,000	2,207	0.044	0.000065	0.000015	0.000015	0.00001 (f)	0.230	0.249	0.256	0.260
(d) When discontinued at 833 hr. (e) When discontinued at 2,184 hr. (f) When discontinued at 2,207 hr. rate was less than 0.0001 percent, elongation was 0.26 percent.												

Table III—Density and Mean Thermal Coefficient of Expansion

Alloy No.	Density, gm. per c. c.	Millionths of an in. per in. per deg. F. for temperature range 70 to 600	70 to 800	70 to 1,000	70 to 1,200	70 to 1,500	70 to 1,600
21	8.2986	7.83	7.96	8.18	8.38	8.68	....
23	8.5385	7.64	7.96	8.18	8.48	9.24	....
27	8.2077	7.53	7.79	8.04	8.29	8.67	8.84
30	8.3137	7.70	7.86	7.91	8.07	8.42	8.54
31	8.6078	....	....	....	....	....	....

precision casting is the preparation of one or more master patterns, which are replicas of the parts desired, except that they are oversize by about 1.5 percent. The oversize compensates for wax and metal shrinkage. From the master pattern, a soft metal die is cast. There are generally from one to twenty cavities in the die, depending upon the size of the part. The aim is to get as many pieces into the die as practical, since with more cavities, each wax injection produces more wax patterns.

Several wax patterns are connected together with gates and risers by wax welding. The assembly is dipped in a solution containing fine silica in suspension. The silica coating accounts for the fine surface finish on precision castings.

After the pouring mouth of the assembly of wax patterns is sealed to a steel plate, the assembly is dehumidified and sealed in a flask. Later the flask is filled with a chemically hardening investment material, vibrated to pack the investment tightly around the wax pattern and to expel all air. Excess investment material is cut off and the mold is allowed to age for several hours. The steel plate is removed, exposing the pouring mouth into which metal ultimately will be poured. The mold is then placed upside down in a continuous furnace and the wax is melted out.

Meanwhile weighed charges of the desired alloy are melted in small indirect arc furnaces. The heated mold is placed over the pouring spout of the furnace and

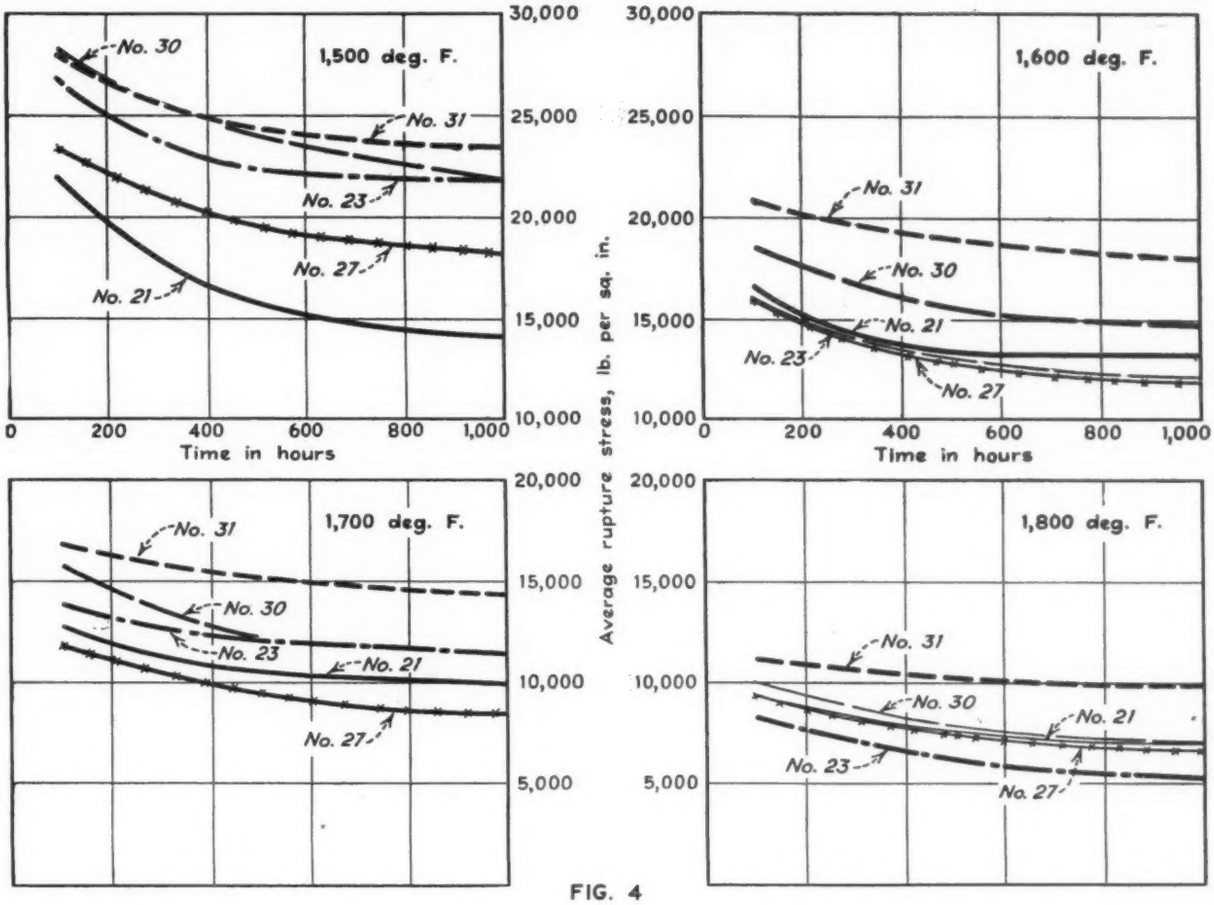


FIG. 4

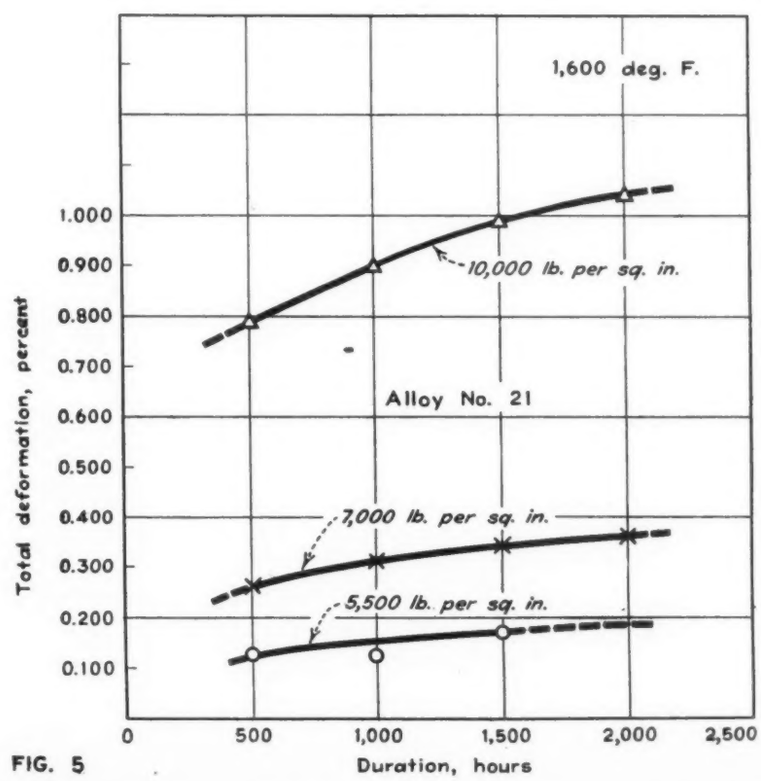


FIG. 5

Fig. 4—Average stress-rupture properties of five alloys for high temperature service.

Fig. 5—Creep test data from Table II can be charted, as illustrated here, for convenience in design calculations.

clamped to it. The furnace is inverted. Gravity assisted by compressed air, causes the void left by the melted wax to fill completely with alloy metal.

The mold is allowed to cool slowly, the cast parts being knocked from the mold about 4 hr. afterward. The gates and risers are cut off; the castings are cleaned, inspected, and made ready for use in the engine or machine for which they were designed.

There is no minimum weight to precision castings, providing the casting meets other dimensional requirements such as minimum section and edge thicknesses. The maximum weight depends largely on how the metal for the part must be poured. Where pressure pouring of the casting is desirable, the maximum weight for the finished part is now about 5 lb. If gravity pour alone can be used, the weight

Table IV—Age Hardening Data From As Cast Condition, Rockwell A Scale

Alloy No.	As Cast	Aging Temperature, deg. F.	Hardness After 1 hr.	2 hr.	5 hr.	24 hr.	50 hr.	100 hr.
21	65	1,350	65	66	66.5	68.5	69.5	71.5
	65	1,500	67	67	68	69	69	71
	67	1,600	69	69	68.5	69	69	70
	64.5	1,600	67.5	67.5	67.5	68.5	68.5	68.5
	65	1,700	66	66.5	67.5	67.5	68	69
23	65	1,350	66	68	69.5	71	71.5	71.5
		1,500	70	69.5	70	70	69.5	69
		1,600	68	68	67.5	68.5	69	69.5
		1,700	68	68	69	69	69	71
27	61	1,350	62	66	66.5	67	67.5	67.5
	59	1,500	65	64.5	65	65	64.5	65
	59.5	1,600	62.5	62.5	62.5	62.5	64	64.5
	61	1,700	62	62.5	63	63.5	64	66
30	65.5	1,500	69	69.5	69.5	70.5	71	73
	65.5	1,600	68	68.5	69	69	70	72
	65.5	1,700	67.5	68.5	69	70	70	72
31	64	1,500	66	69.5	70	69.5	70	70
	64	1,600	66.5	67.5	67.5	67	68	70
	64	1,700	67	68	69	68.5	69.5	71

Table V—Chemical Compositions of High Temperature Alloys

Haynes Stellite Company Name Commonly Called ND RC Reference	HS No. 21 Vitallium NR-10	HS No. 23 61 NR-60	HS No. 27 6059 NR-63	HS No. 30 422-19 NR-12	HS No. 31 X-40
Chromium, percent	28	28	28	28	28
Molybdenum, percent	6		6	6	
Carbon, percent	0.20 to 0.30	0.40 to 0.50	0.40 to 0.50	0.40 to 0.50	0.40 to 0.50
Tungsten, percent		6			5.5
Nickel, percent			32	16	8.5
Balance	Cobalt	Cobalt	Cobalt	Cobalt	Cobalt

is limited only by the sizes of the dies for making the wax patterns.

A soft metal die is made for parts of intricate shapes. The maximum size currently recommended for this type of die is 10 x 12 x 5 in. If the part is simple in shape, and the die can be made from an easily machined material, larger sizes can be used.

The minimum practical wall thickness is about 1/16 in., although thinner sections have been cast successfully. About 0.012 to 0.015 in. is the minimum practical edge thickness. It is difficult to cast a heavy section immediately adjacent to a thin section so that a gradual tapering is preferred to an abrupt sectional change.

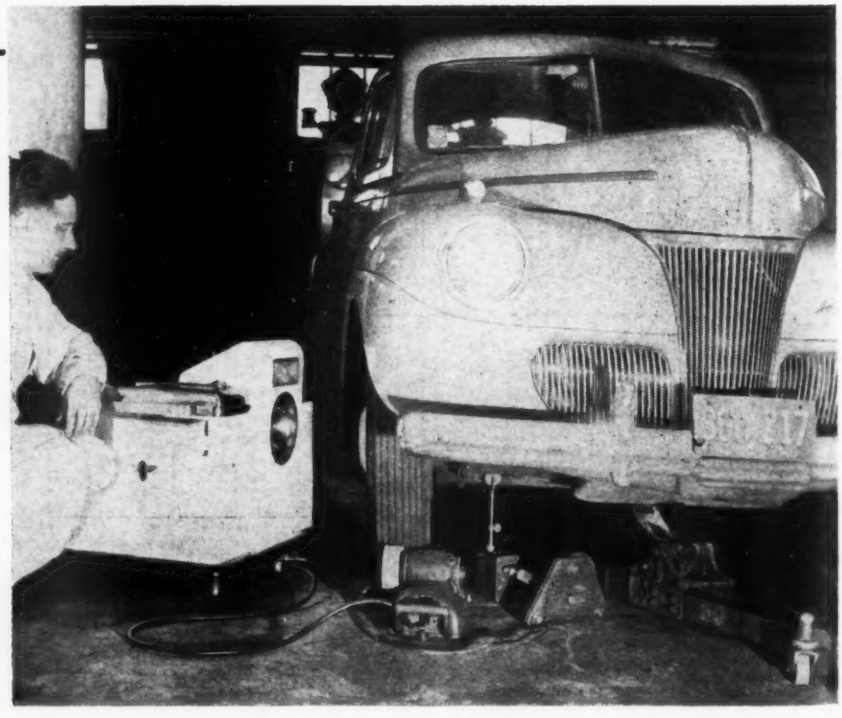
Generally, a small-diameter, shallow hole, say 1/4 in. dia. by 1/2 in. deep, can be held to a tolerance of plus or minus 0.003 in., on both location and diameter. The minimum hole that can be cored depends on the amount of surrounding metal. In thin sections 0.050 in. is a good working minimum. Undercut, recessed holes and internal contours such that the core cannot be readily withdrawn can be cast by the wax process.

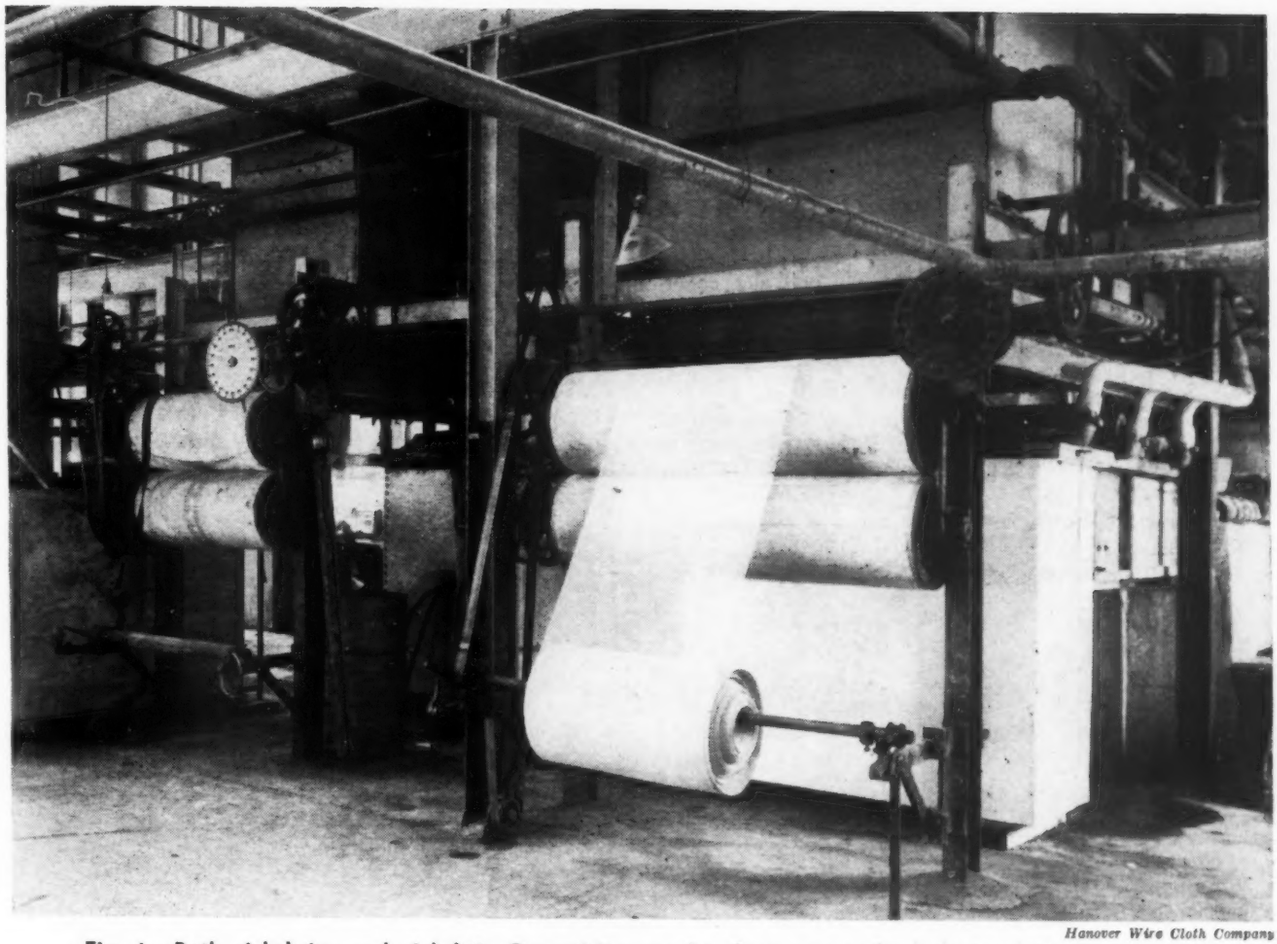
Tolerances between 0.005 and 0.010 in. per in. of length usually can be held on parts as cast. Closer tolerances, though possible on some parts depending upon the size and contours of the parts, are not considered commercially practical. The yield of satisfactory castings is directly proportional to the tolerances allowed on them. On surfaces that must be finished by machining or grinding, an allowance of from 0.015 to 0.040 in. is ample.

Electronic Wheel Balancer

VIBRATION set up by unbalance is picked up by a magnetic unit under axle. Dial reading indicates degree of unbalance and actuates stroboscopic light, which indicates point of unbalance. Operator then corrects unbalance by applying weights. A product of the Stewart-Warner Corporation, Chicago, the unit operates from single 110 volt a.c. plug-in.

The electronic assembly of the balancer, including the stroboscopic light, is inclosed in a portable, castered cabinet 26 in. high, 30 in. wide and 20 in. from front to back. Cabinet has baked enamel finish, with polished steel top and stainless steel trim.





Hanover Wire Cloth Company

Fig. 1—Both nickel-zinc and nickel-tin Corronizing can be done on standard electroplating equipment.

Nickel Zinc and Nickel Tin Corrosion Resistant Metal Coatings

L. C. CONRADI
Standard Steel Spring Company

Double plated metals subsequently heat-treated to improve corrosion resistance. Plating materials, suitable thicknesses of plating and relative cost, together with typical data on effectiveness of Corronizing from salt spray tests and information for use in design are discussed.

IN THE QUEST for materials, design engineers are finding an increasing variety of applications for products coated with nickel zinc and nickel tin. Sheet, tube, mesh, diced and perforated materials, as well as many other parts, however intricate and irregular in shape, can be coated readily by a process known and patented under the trade name of "Corronizing."

Both types of metal coatings are corrosion resistant, protection against corrosion being a primary reason for using them. Nickel-zinc Corronizing is suitable for designs where heat, water or moisture, sulphur dioxide, sulphur trioxide and other gases combine to form severe corrosive conditions, where salt spray and chemical fumes exist and where brines and other chemical solutions are handled. Thus automobile exhaust mufflers, fuel tanks, coal stoker parts, coal, gas- and oil-burner parts, flues, breechings, chemical hoods, spray booths, filters, coolers, chemical condensers and fume washers are representative parts and equipment that have been protected against corrosion by nickel-zinc Corronizing.

Nickel-tin Corronizing is suitable for food containers, for parts of food handling and processing equipment and for other

parts where tin plate is normally used. In addition it is suitable for a variety of metal parts where a decorative finish is desirable, or required.

Nickel-zinc Corronizing is slate grey in color and as such is not a decorative finish. Paint adheres to the surface if the alloying has been controlled so as to eliminate free zinc. To be on the safe side the designer can specify the application of a chromic acid or phosphate solution preliminary to painting. A five percent solution of chromic acid or a one percent solution of sodium acid phosphate is effective.

The nickel-tin coating by virtue of its outermost layer of free tin has the appearance of conventional matte finish on tin plate. It can be lacquered in the same manner as tin plate.

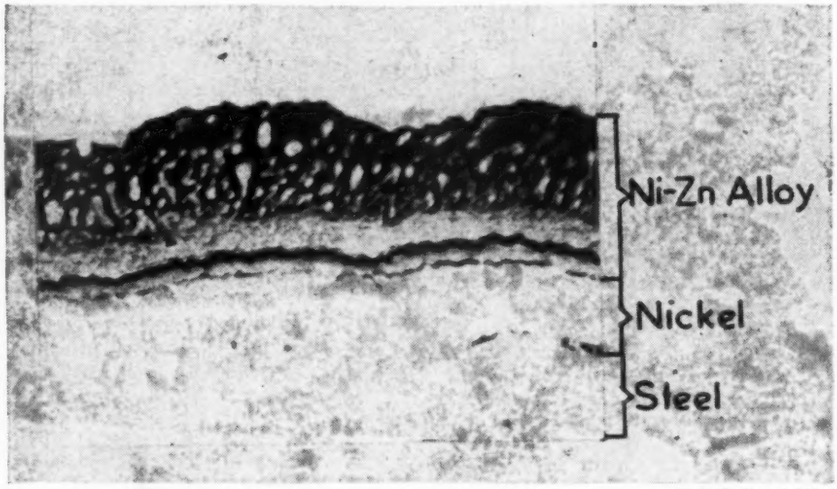
Three operations comprise the process of Corronizing. First, the base metal, steel, bronze, brass or other metal, is electroplated with nickel. Second, zinc or tin, is electroplated directly over the nickel plate. Third, the double plated part is heat-treated, usually at 700 deg. F. for nickel-zinc and 350 deg. F. for nickel-tin coating.

Heat-treating after plating diffuses the plating materials, alloying them more or less into layers, Fig. 2. The layer next to the base metal is nickel. The surface layer is nickel-zinc alloy or free tin, depending on the type of Corronizing. The intermediate layers are alloy phases of the two plating materials. This composite coating offers dual protection and better corrosion resistance than nickel or zinc or tin alone.

Drawing-room practice is to specify Corronizing by a letter-number symbol. The letters A, B and C indicate that the thickness of the nickel is 3/4, 1/2 and 1/4, respectively, of the total coating thickness. A number following the letter denotes the total thickness of the coating in millionths of an inch. For example A-6 designates a coating 600 millionths of an inch in thickness where the nickel is 450 and the zinc 150 millionths of the total.

Many parts are Corronized as a last operation of manufacture. At this stage all exposed areas, however caused during manufacture, are effectively coated and protected against corrosion. Forming and drawing of the part can be done after Corronizing if the base metal used is ductile enough to permit such operations. Nickel-zinc Corronizing does not interfere with spot, seam and arc welding, nor with brazing and soldering operations. The nickel-tin coating can be formed, soldered and seamed like tin plate provided black oxidized stock or material of equal ductility is used as the base metal.

On the other hand, the designer can call for Corronizing at stages in manufacture other than the last—often to great advantage. For example, a design of wire



Magnification 2,000 ×

Fig. 2—Cross-section of Corronized sheet steel.

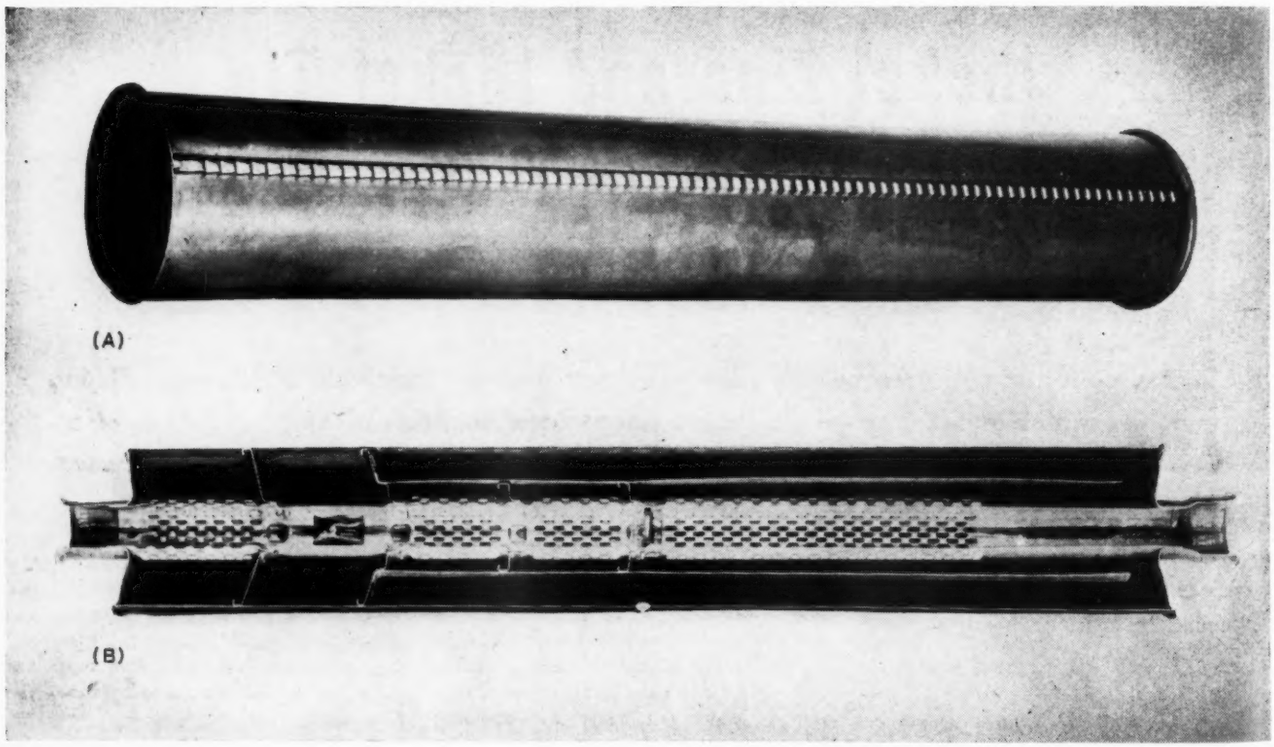


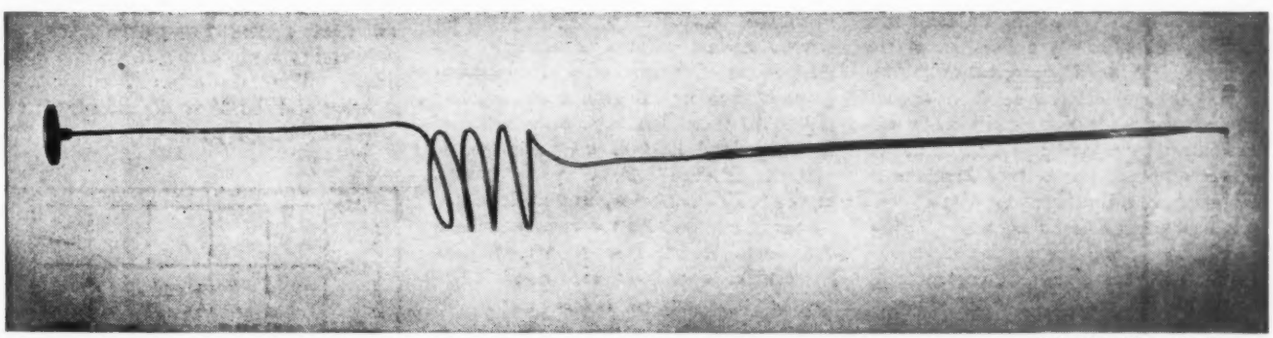
Fig. 3—Automobile exhaust muffler. The shell is formed, double seamed and crimped from Corronized sheet. The interior is made from Corronized sheet steel by forming, drawing, double seaming, crimping and spot welding.

Table I—Typical Data on Corrosion Resistance of Corronized Sheet to Salt Spray
(Small, medium and large refers to size of rust spot)

Type of Corronizing	Coating Thickness, Millionths of an Inch		Number and Size of Rust Spots After			
	Nickel	Zinc	144 Hr.	240 Hr.	500 Hr.	1,032 Hr.
A-4	300	100	.....	1 pin point	Many pin points surrounded by white spots	2 small — some pin points
A-6	450	150	.....	.....	1 pin point	1 med. at edge, some small, some pin points
B-4	200	200	.....	1 pin point	1 small — many pin points	1 large, some small, many pin points at top left
B-6	300	300	.....	.....	Some pin points along edge	1 med. at edge, some pin points
C-4	100	300	.....	1 pin point	A few pin points	1 med., some small, some pin points
C-6	150	450	.....	.....	1 small, some pin points	1 small, some pin points
Electroplated No Heat-treatment						
Zn only	...	400	Many pin points	15 percent rust	80 percent	90 percent rust in 790 hr.
Zn only	...	600	1 pin point	1 large, some pin points	2 percent rust	90 percent rust
Ni+Zn	200	200	2 pin points	1 very large 1 med., some pin points	2 percent rust	60 percent rust
Ni+Zn	300	300	Many pin points	Many pin points	1 percent rust (along edges)	25 percent rust

Table II—Approximate Cost of Corronizing a 24 Gage 36x108 in. Sheet, or 54 sq. feet
Nickel at 46 cents; Zinc at 9.28 cents per pound

Type of Corronizing	Coating Thickness, Millionths of an in.		Plating Speed, ft. per min.	Sheets per hr.	Tons, per mo.	Metal Cost, Cts. per Sq. Ft.		Total Cost	
	Nickel	Zinc				Nickel	Zinc	Cents, per sq. ft.	Dollars, per ton
A-4	300	100	16.6	110.6	788	0.639	0.034	1.02	40.58
A-6	450	150	11.1	74	528	0.959	0.052	1.485	59.54
B-4	200	200	25	166.6	1187	0.426	0.068	0.768	30.72
B-6	300	300	16.6	110.6	789	0.639	0.103	1.12	44.80
C-4	100	300	16.6	110.6	789	0.213	0.103	0.574	22.94
C-6	150	450	11.1	74	527	0.319	0.154	0.828	33.10



Robertshow Thermostat Company

Fig. 4—Thermostats such as this are Corronized in quantities by production line methods.

screen for economical coating is based on a production line in which the screen is unrolled, passed through the electrolytes and then rerolled, rather than a batch treatment of pieces of screen after they have been cut to size.

Comparative results of the corrosion resistance of several grades of Corronized plate to salt spray are described in Table I. The operation of salt spray was in accordance with ASTM specification. Careful and immediate examination for the extent of corrosion of the dried test specimen was made after the periods tabulated.

Cleaning solutions and nature of cleaning, concentrations of electrolytes, current density and plating procedure commonly used in electroplating are applicable in Corronizing. The same degree of care and technique also apply. Methods that conform to ASTM standards are recommended.

Cost of Corronizing can be estimated from present plating costs plus the cost of heat-treatment after plating. Table II contains typical cost data. These data include labor, plating material, current drag-out losses, allowance for rejections, and heat-treatment. They do not include the cost of the base metal and overhead.

Fatigue Strength of Steel Forgings

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G. NOLL
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Editor's Note: **There seems to be considerable misunderstanding concerning the fatigue strength of forged steel parts used in the as-forged conditions. This is borne out by the great amount of discussion and comment that developed after the presentation of the paper "Allowable Working Stresses," by C. Lipson and G. Noll, at the 1945 annual meeting of the Society for Experimental Stress Analysis, and its publication in "Experimental Stress Analysis" Vol. 3 No. 2, 1946 (Addison-Wesley Press, Inc.) and the publication of the article "Allowable Working Stresses for Steel" in the March 1946 issue of *Product Engineering*. The editor asked the authors to clarify this matter in an article and the following is Messrs. Lipson's and Noll's presentation.**

CHARTS given in both the paper and the article show the endurance limits of steel parts in as-forged condition to be appreciably lower than when the surface was machined or ground. Some readers misinterpreted the data to mean that the forging of steel lowered its fatigue strength. It should be emphasized that it is not the forging process that is responsible for the lower fatigue strength, but rather the character of the as-forged surface associated with the forging operation. Thus the difference in the fatigue strength of ground, machined, and as-forged parts, all made of the same steel and all having the same core hardness, are primarily a function of the surface conditions. On account of the nature of the manufacturing operations necessary for their production, steel forgings will inherently have surface decarburization with a resultant low surface hardness as compared with the hardness of the core. This condition, together with surface irregularities, possibly scale inclusion, surface pits and other surface defects naturally lowers the fatigue strength of the as-forged part.

The types of forging furnaces, their operation, and the manner of handling the pieces during and after forging, all contribute to establishing the character of the surface of the as-forged part. These conditions will vary in the different shops and therefore it can be expected that there will be a broad range in the qualities of the forging surfaces.

This in turn will be reflected in the fatigue strength. Parts having a small amount of decarburization and slight surface irregularities will exhibit higher strength than parts where these conditions are more severe. G. A. Hankins and M. L. Becker state in their article "The Fatigue Resistance of Unmachined Forged Steels," published in the *Journal of the Iron and Steel Institute*, Vol. 126, No. 2, M 32, p. 210: "Further it will be found...that the materials (forgings) which show the more marked differences between surface and interior hardness are those which give the more marked differences between the fatigue limits in the unmachined and machined conditions."

This is illustrated in Fig. 1 where the endurance limits of as-forged parts are plotted against the tensile strength. For the purpose of comparison a corresponding graph is given for the ground and polished parts. All these data have been corrected for size effect and they refer therefore to parts larger than 1/2 in. at the critical section. This correction was made in the following manner: All the endurance limit data found in literature or derived from the authors' own tests, and pertaining to specimens larger than 1/2 in. and up to 2 in. (since insufficient information is available for parts over 2 in.) were corrected for size by multiplying data derived from small specimen testing (such as R. R. Moore) by 0.85. This takes into account 15 percent decrease in fatigue strength of large parts relative to small (0.240 in.) specimens. For parts between 0.250 and 0.500 in. in size the correction was made proportionally.

It will be noted in Fig. 1 that there seems to be a broad range in the fatigue strength data applicable to as-forged surfaces. The upper limits refer to what may be termed as controlled forging operation, while the lower limits apply to standard large scale manufacturing practices. (Hankins, G. A., and Becker, M. L., "Further Experiments on the Effect of Surface Conditions on the Fatigue Resistance of Steels," the *Journal of the Iron and Steel Institute*, Vol. 133, No. 1, 1936.) The former have a small amount of decarburization, less than 0.005 in partial decarb, and correspondingly smaller differences between the surface and core hardness. They are also characterized by less pronounced surface pits and fewer inclusions and surface irregularities. The lower limits of the graph have a much more pronounced decarburized layer ranging from 0.012 up to 0.035 in. and a large difference between the surface and core hardness. (See Figs. 2 to 9). Surface irregularities and defects are correspondingly much more severe, all this leading to a low fatigue strength.

The authors, both in their paper before the Society for Experimental Stress Analysis and their article published in PRODUCT ENGINEERING, used this lower limit of the graph for the determination of the allowable working stresses for the as-forged surfaces. This was in line with their basic purpose to provide engineers and designers with a convenient design code for the determination of allowable working stresses. The values presented were obtained by tests on forgings made under commercial conditions. Thus, the values given are conservative and should be dependable for use in general design practice.

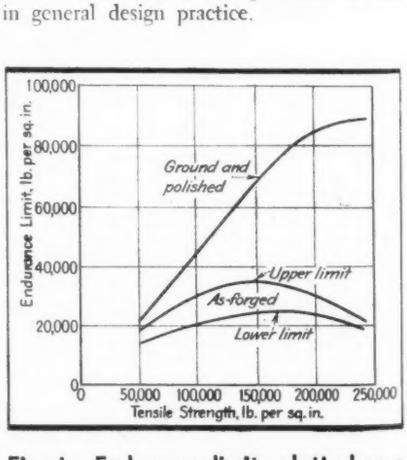


Fig. 1—Endurance limits plotted as a function of the tensile strength for parts having ground-and-polished and parts having as-forged surfaces.

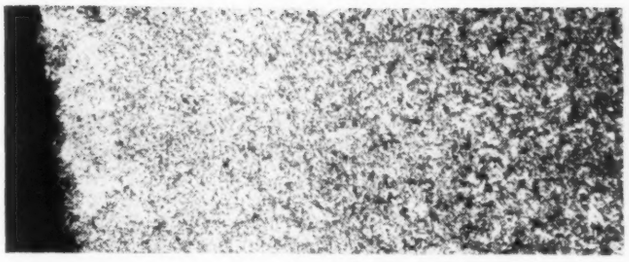


Fig. 2—Photomicrograph of a section of a carbon-moly steel part, quenched and tempered, as-forged surface, at 100 magnification, nital etch, showing partial decarburization ranging from 0.025 to 0.030 in. deep.

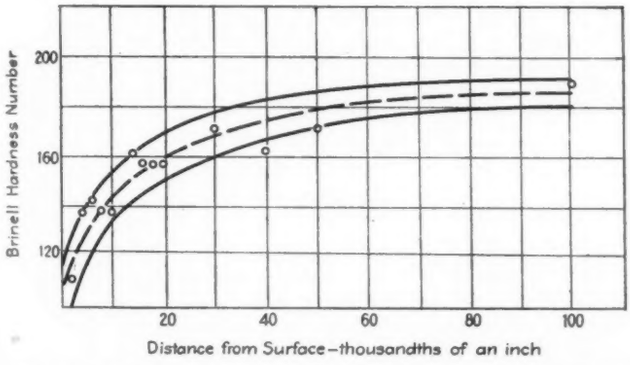


Fig. 3—Microhardness traverse hardness values from 200 gram Vickers on Tukon hardness tester, across the section of a carbon-moly steel part, quenched and tempered, with as-forged surface.

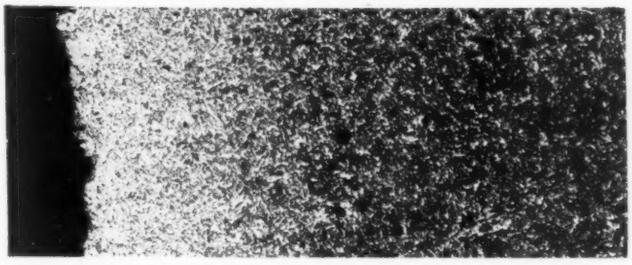


Fig. 4—Photomicrograph of a section of an SAE 1340 steel part quenched and tempered, as-forged surface, at 100 magnification, nital etch, showing partial decarburization ranging from 0.010 to 0.012 in. deep.

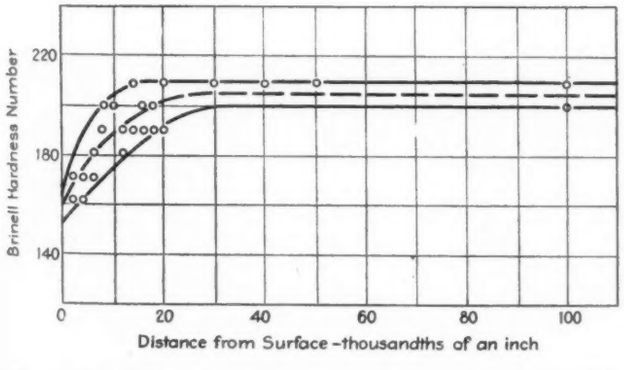


Fig. 5—Microhardness traverse hardness values from 200 gram Vickers on Tukon hardness tester, across the section of an SAE 1340 steel part, quenched and tempered, with as-forged surface.

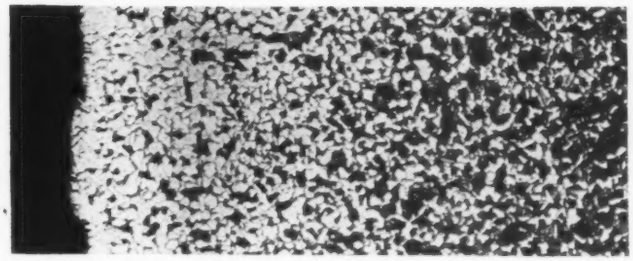


Fig. 6—Photomicrograph of a section of an SAE 3135 steel part, quenched and tempered, as-forged surface, at 100 magnification, nital etch, showing partial decarburization ranging from 0.030 to 0.035 in. deep.

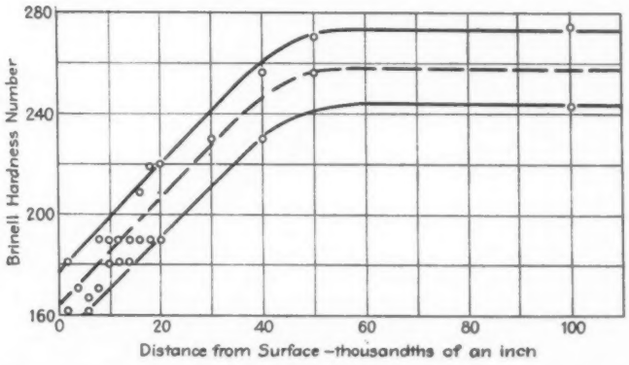


Fig. 7—Microhardness traverse hardness values from 200 gram Vickers on Tukon hardness tester, across the section of an SAE 3135 steel part, quenched and tempered, with as-forged surface.

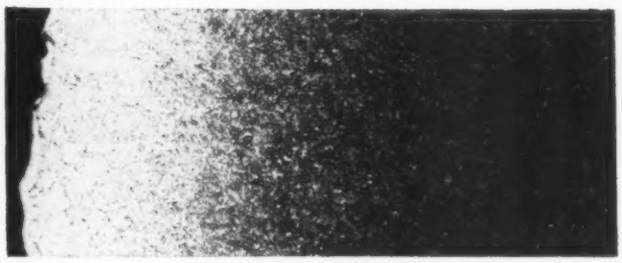


Fig. 8—Photomicrograph of a section of an NE 8650 steel part, quenched and tempered, as-forged surface at 100 magnification, chrome plated nital etch, showing partial decarburization ranging from 0.012 to 0.015 in. deep.

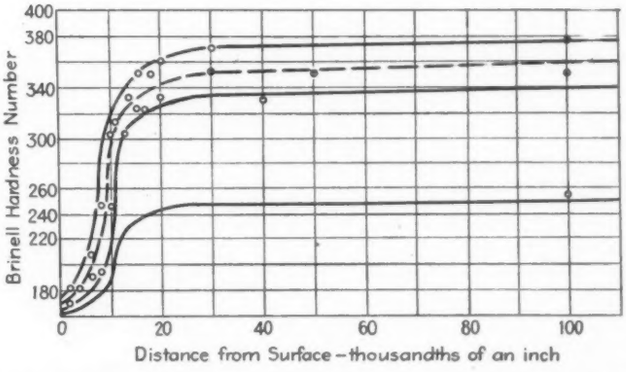


Fig. 9—Microhardness traverse hardness value from 200 gram Vickers on Tukon hardness tester across the section of an NE 8650 steel part, quenched and tempered with as-forged surface.

LIMIT SWITCHES
Their Selection and Characteristics

C. S. KIDD
Engineer, Allen-Bradley Company

Analysis of mechanical and electrical characteristics that should be considered when applying limit switches to machines. Right and wrong methods, various operating mechanisms, typical built-in arrangements, and electrical contact arrangements are included.

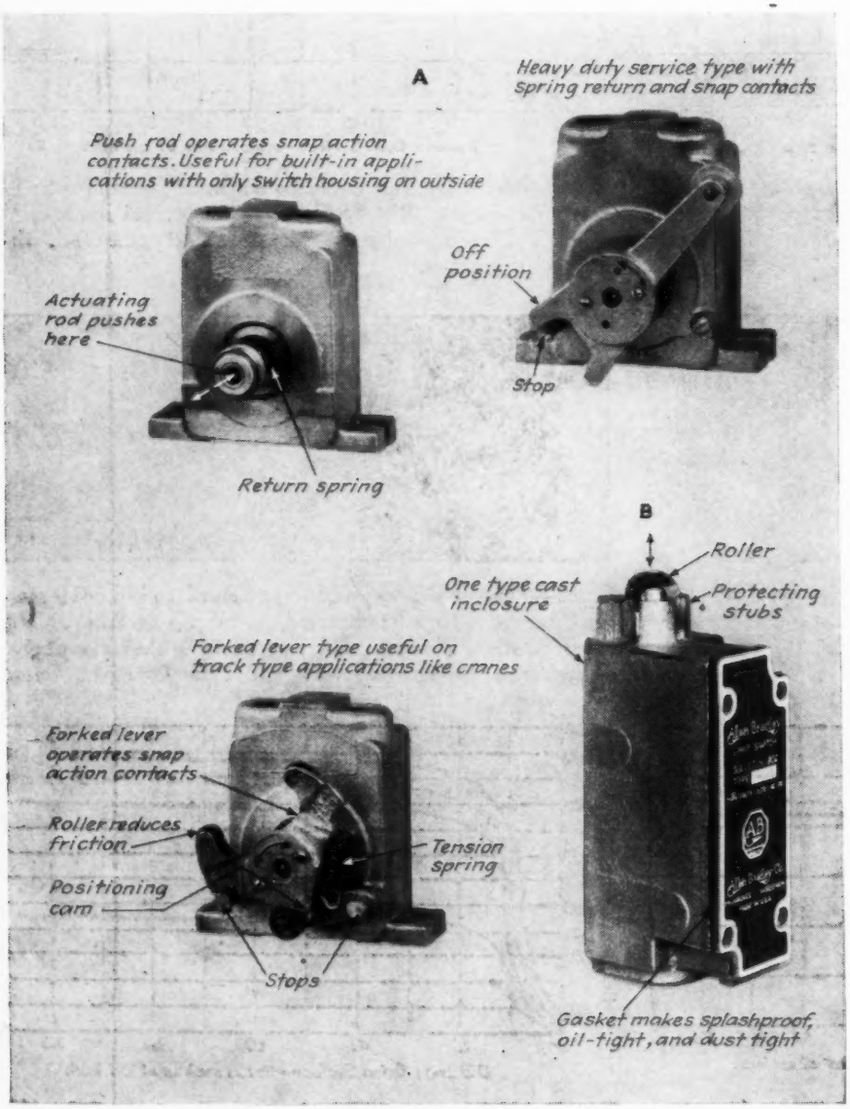

A
Heavy duty service type with spring return and snap contacts
Push rod operates snap action contacts. Useful for built-in applications with only switch housing on outside
Off position
Actuating rod pushes here
Stop
Return spring
B
Roller
One type cast inclosure
Protecting stubs
Forked lever type useful on track type applications like cranes
Forked lever operates snap action contacts
Roller reduces friction
Tension spring
Positioning cam
Stops
Gasket makes splashproof, oil-tight, and dust tight

Fig. 1—Several types of limit switches, (A) Heavy duty limit switches in watertight or explosion proof cast iron inclosures. (B) Precision type, spring return limit switch with snap-acting contacts for high accuracy on severe service.

LIMIT SWITCHES can be defined as electric current switching devices that are operated by some type of mechanical motion. Limit switches find their greatest field of application on automatic machinery by controlling a complete operating cycle automatically by closing and opening electrical circuits in the proper sequence.

In addition to interlocking control circuits, limit switches have many other uses. For example, one of the most important is as safety devices to stop a machine, sound a warning signal, or illuminate a warning light when a dangerous operating condition develops. Thus, properly applied switches can both control highly efficient automatic electric machinery and protect it and the operator.

The many factors to be considered in the proper selection of limit switches can be grouped as: Mechanical and electrical. Each group is equally important, since both work hand-in-hand to control the proper operation of a machine.

Mechanical Factors

The primary mechanical factor to be considered is the motion that is to operate the limit switch. The main factors of motion to be determined are: (1) Whether the motion is linear or rotary, (2) the travel available to operate the switch, (3) the speed of operation, (4) the force available for operating, (5) the accuracy required, and (6) the overtravel after the limit switch has been actuated.

Limit switches can be divided into two classes depening upon the accuracy required. The first, for applications where no great degree of accuracy is required, and the second, for precision applications where the limits must operate on a few thousandths of an inch. Usually sufficient force is available to operate the switch where no great degree of accuracy is required, however, on precision applications force is often a critical factor. Several typical types of limit switches are shown in Fig. 1. Precision limit switches are a comparatively recent development and are increasingly used both for their accuracy and small size. Although the compactness of precision switches limits the contact arrangements and current carrying capacity,

these limitations can be overcome by the use of pilot switching devices.

After determining the nature of the motion, it is necessary to find the proper means of transmitting this motion to the limit switch. The use of incorrect operating means can cause maintenance difficulties as well as delayed production. Possible operating means are infinite; therefore extreme care should be used to select a correct method.

Proper transmission is achieved primarily through the selection of a type of operating means that can be easily adapted to the particular motion. As shown in Fig. 2, selection should be made so that no sharp hammer blows are delivered to the lever and so that no forces are set up that would tend to move the lever in directions other than those for which it was designed. The diagrams in Fig. 2 are suggested ideas for applying various types of limit switches. They do not imply that the method suggested must be used although such method of application will result in a reliable and long life operation of the limit switch. In applying limit switches consideration must be given to the frequency with which the limit switch is operated. Sketches that are labelled "wrong" may be quite satisfactory, if the limit switch is thus applied for light duty service. It is entirely possible that there may be no other method for installing the limit switch than in the "wrong" way. This type of installation becomes "wrong" and trouble-causing primarily in frequent service, so for such service should be avoided if possible.

In applying limit switches there should be no possibility of the operating lever being forced beyond its normal stopping point. Also, the return spring of the limit switch should be required to move only the limit switch lever itself.

In some applications the limit switch can be mounted so that the moving part of the machine itself actuates the limit, in others, an extension or boss must be added to the moving part. Proper operation depends largely on the shape or taper of these extensions, or "tripping dogs."

The numerous types of levers that are used to operate limit switches can be roughly classified into six basic groups as follows: (1) Roller, (2) push rod, (3) fork, (4) rod or chain, (5) stroke, and (6) weight operated. The more commonly used types are the roller and push rod but each of the other types has a field of useful application. Fig. 3 shows various types of operating levers with typical coupling methods.

The foregoing description and charts show means of transmitting both linear and

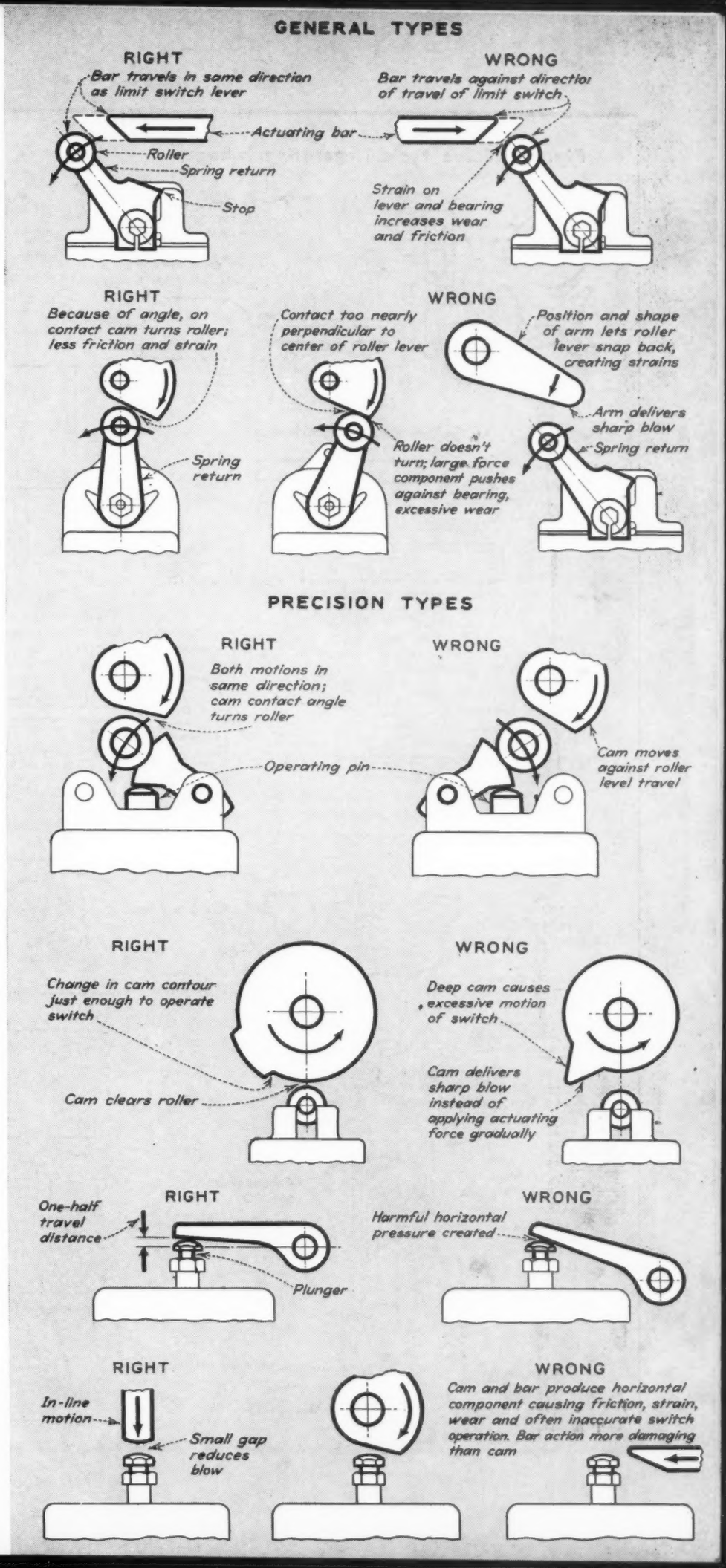
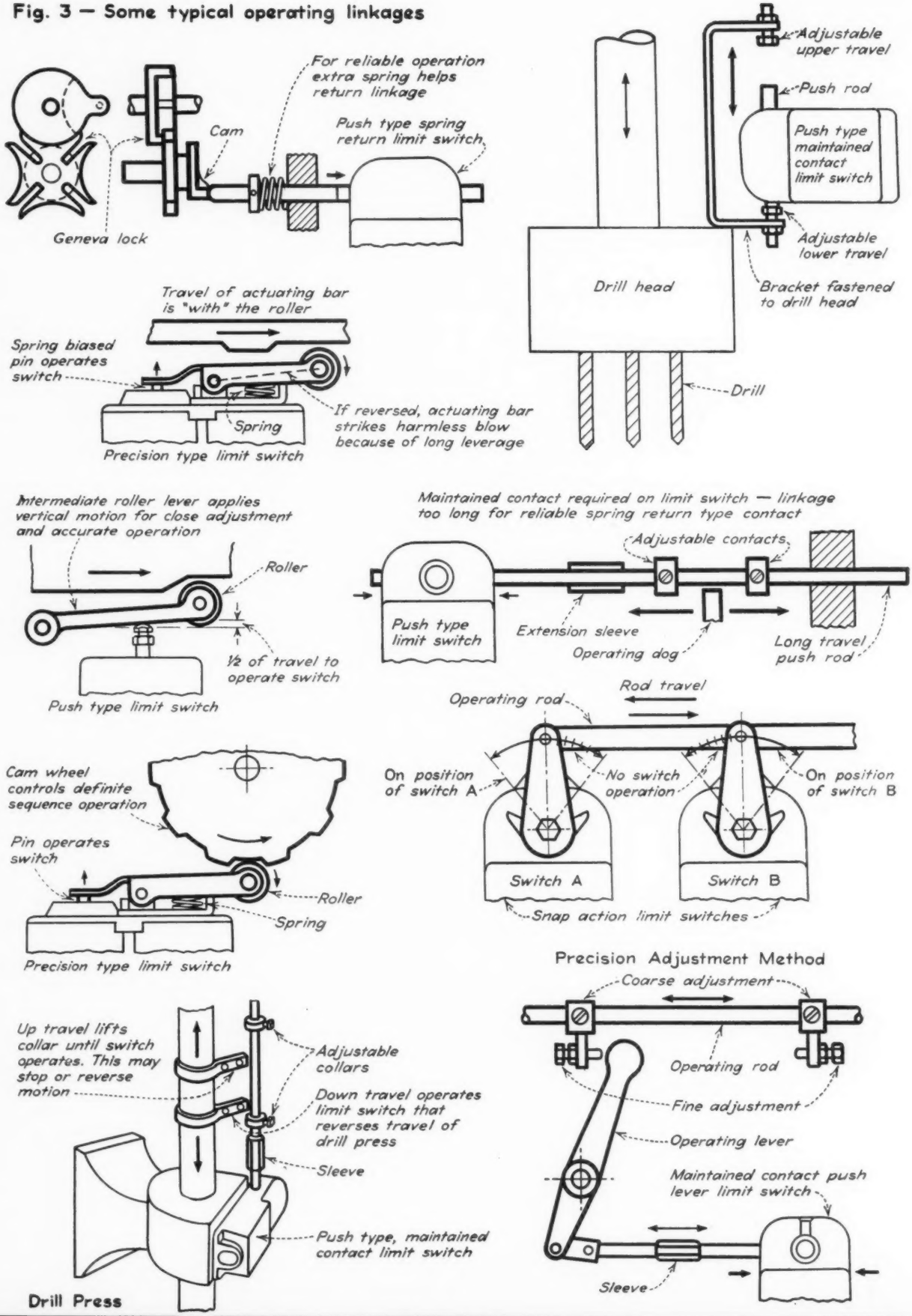
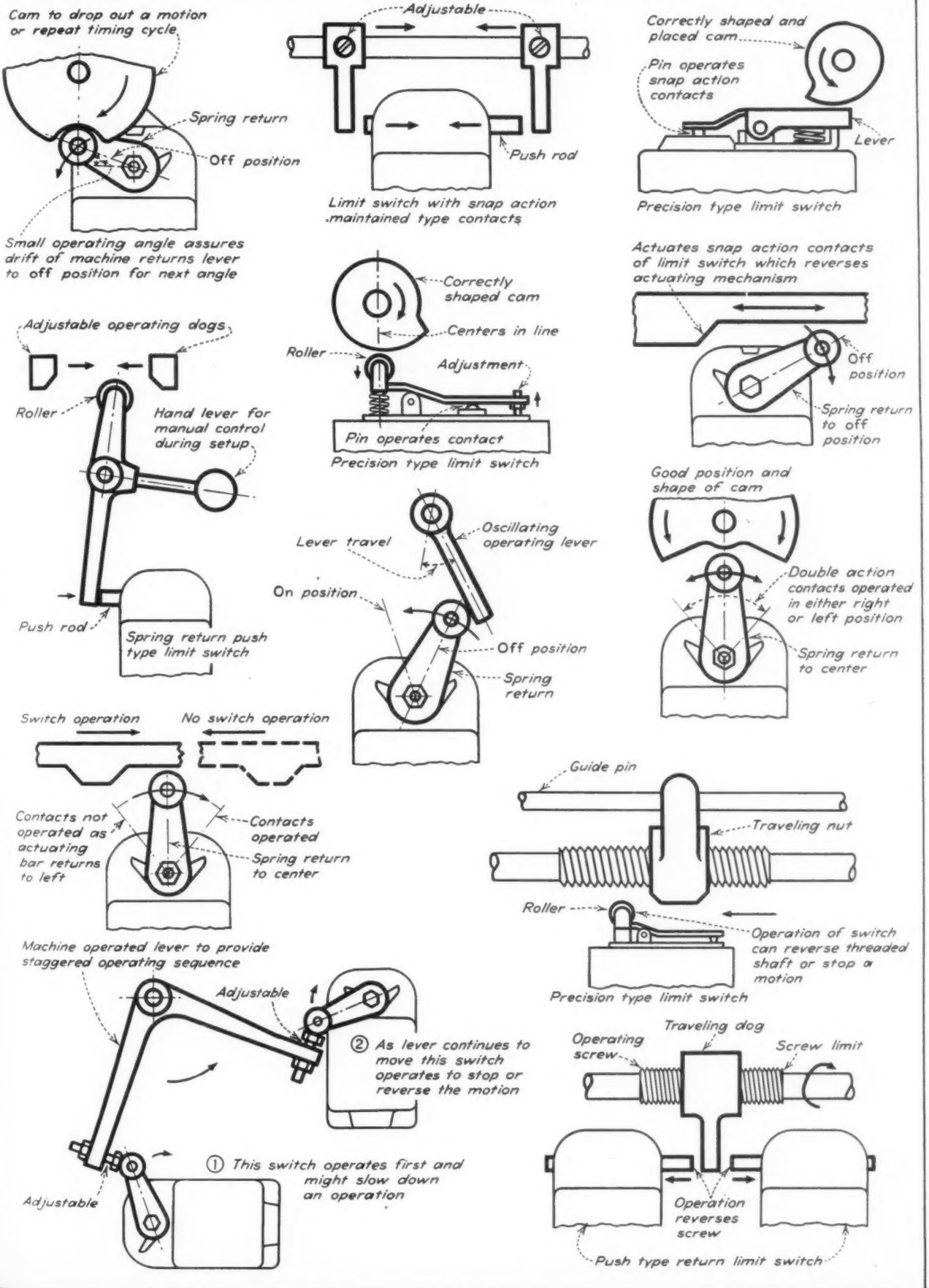

GENERAL TYPES
RIGHT
Bar travels in same direction as limit switch lever
Actuating bar
Roller
Spring return
Stop
WRONG
Bar travels against direction of travel of limit switch
Strain on lever and bearing increases wear and friction
RIGHT
Because of angle, on contact cam turns roller; less friction and strain
Spring return
WRONG
Contact too nearly perpendicular to center of roller lever
Roller doesn't turn; large force component pushes against bearing, excessive wear
Position and shape of arm lets roller lever snap back, creating strains
Arm delivers sharp blow
Spring return
PRECISION TYPES
RIGHT
Both motions in same direction; cam contact angle turns roller
Operating pin
WRONG
Cam moves against roller level travel
RIGHT
Change in cam contour just enough to operate switch
Cam clears roller
WRONG
Deep cam causes excessive motion of switch
Cam delivers sharp blow instead of applying actuating force gradually
RIGHT
One-half travel distance
Plunger
WRONG
Harmful horizontal pressure created
RIGHT
In-line motion
Small gap reduces blow
WRONG
Cam and bar produce horizontal component causing friction, strain, wear and often inaccurate switch operation. Bar action more damaging than cam

Fig. 2 — Some right and wrong methods of applying limit switches for most reliable operation on severe duty cycles and best life expectancy.

Fig. 3 — Some typical operating linkages


For reliable operation extra spring helps return linkage
Cam
Push type spring return limit switch
Geneva lock
Adjustable upper travel
Push rod
Push type maintained contact limit switch
Adjustable lower travel
Drill head
Bracket fastened to drill head
Drill
Travel of actuating bar is "with" the roller
Spring biased pin operates switch
Spring
If reversed, actuating bar strikes harmless blow because of long leverage
Precision type limit switch
Intermediate roller lever applies vertical motion for close adjustment and accurate operation
Roller
½ of travel to operate switch
Push type limit switch
Maintained contact required on limit switch — linkage too long for reliable spring return type contact
Adjustable contacts
Push type limit switch
Extension sleeve
Operating dog
Long travel push rod
Rod travel
Operating rod
On position of switch A
No switch operation
On position of switch B
Switch A
Switch B
Snap action limit switches
Cam wheel controls definite sequence operation
Pin operates switch
Roller
Spring
Precision type limit switch
Precision Adjustment Method
Coarse adjustment
Operating rod
Fine adjustment
Operating lever
Maintained contact push lever limit switch
Sleeve
Up travel lifts collar until switch operates. This may stop or reverse motion
Adjustable collars
Down travel operates limit switch that reverses travel of drill press
Sleeve
Push type, maintained contact limit switch
Drill Press


Cam to drop out a motion or repeat timing cycle
Spring return
Off position
Small operating angle assures drift of machine returns lever to off position for next angle
Adjustable
Push rod
Limit switch with snap action maintained type contacts
Correctly shaped and placed cam
Pin operates snap action contacts
Lever
Precision type limit switch
Actuates snap action contacts of limit switch which reverses actuating mechanism
Off position
Spring return to off position
Correctly shaped cam
Centers in line
Roller
Adjustment
Pin operates contact
Precision type limit switch
Adjustable operating dogs
Roller
Hand lever for manual control during setup
Push rod
Spring return push type limit switch
Lever travel
Oscillating operating lever
On position
Off position
Spring return
Good position and shape of cam
Double action contacts operated in either right or left position
Spring return to center
Switch operation
No switch operation
Contacts not operated as actuating bar returns to left
Contacts operated
Spring return to center
Guide pin
Traveling nut
Roller
Operation of switch can reverse threaded shaft or stop a motion
Precision type limit switch
Machine operated lever to provide staggered operating sequence
Adjustable
② As lever continues to move this switch operates to stop or reverse the motion
① This switch operates first and might slow down an operation
Adjustable
Traveling dog
Operating screw
Screw limit
Operation reverses screw
Push type return limit switch

rotary motion to lever operated limit switches. However, where a machine must operate with respect to a given number of revolutions of a certain rotating part, a different type of mechanism must be used. This type of application requires the use of a rotary motion limit switch that is coupled to the rotating part of the machine by any of the standard means of shaft coupling. In selecting a rotary motion limit switch, the required number of revolutions between changes in the operating sequence must be known. In some instances it is necessary to use gear reducer units to obtain this sequence. Fig. 4 shows several typical rotary motion limit switches and coupling methods.

Mounting is another factor that enters into the selection of limit switches. The physical area available for mounting must be considered and a unit selected that can be mounted in this area allowing room for electrical connections and maintenance. Here the importance of planning for limit switches when the machine is designed is immediately apparent.

All limit switches should be rigidly mounted to the machine to insure trouble-free operation. Limit switches mounted within a machine inclosure have advantages over externally mounted units because operation is usually more simple, unauthorized persons cannot tamper with the units, and the neat overall machine appearance is pleasing. However, unless the machine is skillfully designed the switches may not be as accessible for maintenance.

The proximity of oil or coolant sprays presents another mounting problem since no liquid should come into direct contact with internal operating parts of limit switches. If it is impossible to mount the unit away from the liquid, a water or oil tight inclosure should be used. Limit switches surrounded by explosive atmospheres should use explosion proof inclosures. As shown in Fig. 5, some machine designers use open type limit switches and mount them in their own watertight, oiltight or explosion-proof inclosures within the machine.

Electrical Factors

Electrical considerations in limit switch selection are quite numerous since a knowledge of both the mechanical sequence and

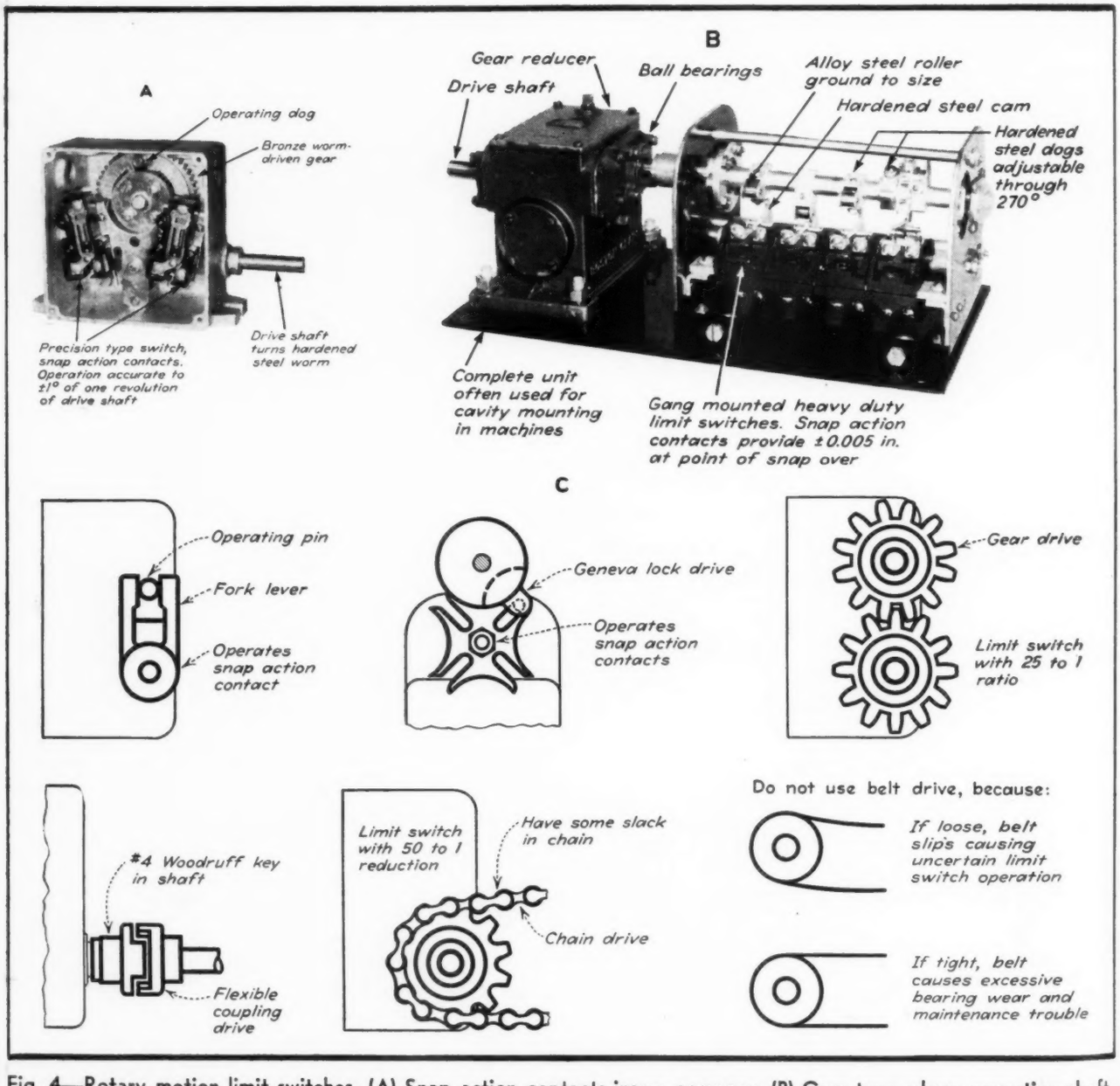

A
Operating dog
Bronze worm-driven gear
Precision type switch, snap action contacts. Operation accurate to ±1° of one revolution of drive shaft
Drive shaft turns hardened steel worm
B
Gear reducer
Drive shaft
Ball bearings
Alloy steel roller ground to size
Hardened steel cam
Hardened steel dogs adjustable through 270°
Complete unit often used for cavity mounting in machines
Gang mounted heavy duty limit switches. Snap action contacts provide ±0.005 in. at point of snap over
C
Operating pin
Fork lever
Operates snap action contact
Geneva lock drive
Operates snap action contacts
Gear drive
Limit switch with 25 to 1 ratio
#4 Woodruff key in shaft
Flexible coupling drive
Limit switch with 50 to 1 reduction
Have some slack in chain
Chain drive
Do not use belt drive, because:
If loose, belt slips causing uncertain limit switch operation
If tight, belt causes excessive bearing wear and maintenance trouble

Fig. 4—Rotary motion limit switches. (A) Snap action contacts insure accuracy. (B) Cam type where operating shaft runs at high speed. (C) Typical coupling methods and a caution in use of belt drives for rotary switches.

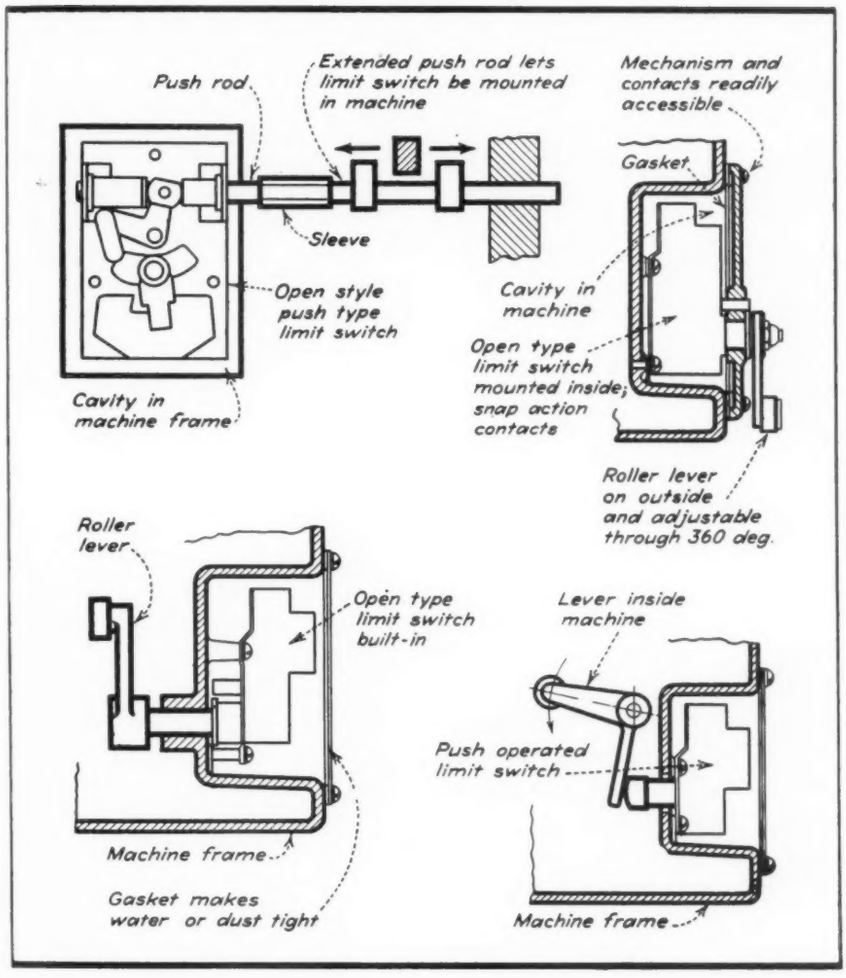

Push rod
Extended push rod lets limit switch be mounted in machine
Mechanism and contacts readily accessible
Gasket
Sleeve
Open style push type limit switch
Cavity in machine
Open type limit switch mounted inside; snap action contacts
Cavity in machine frame
Roller lever on outside and adjustable through 360 deg.
Roller lever
Open type limit switch built-in
Lever inside machine
Push operated limit switch
Machine frame
Gasket makes water or dust tight
Machine frame

Fig. 5—Several arrangements of open type limit switches that are especially useful for built-in applications. Inclosures can be made water and oiltight.

the electrical means of producing this sequence must be known. Automatic machines are usually driven by electric motors or hydraulic or pneumatic systems. The control of these various means of producing motion requires the use of magnetic motor starters, solenoid valves, relays, timers, and other control devices in conjunction with limit switches. Therefore, in selecting limit switches, it is necessary to know what changes are to be secured in the mechanical motion and how to best obtain these changes electrically.

The characteristics of the electrical circuits determine the type of contacts required for the limit switches. Some contact types are shown in Fig. 6 and many variations of them are often used with the operating motions and systems in Fig. 3 for typical applications.

Contact arrangement also must be considered with respect to the overall performance of the electrical circuit. It may be necessary for the contacts to remain in their actuated position after the actuating force is removed or it may be necessary for the contacts to return to their normal position by spring action. These are known as maintained contact type and spring return type.

Another factor in the selection of limit switches is the rating of the load the contacts will be required to carry. It is advisable to allow extra capacity where frequent operation is required.

Either of two basic types of contact action are used in most limit switches: Slow acting or snap acting. In slow acting switches the contact motion is in direct proportion to the lever motion. This action is like that of an ordinary door bell pushbutton. In snap action switches, when the lever has reached a certain point in its travel the contacts snap over to their actuated position. This action is like that of a household light switch.

Slow acting units are usually less costly but their use is limited and depends upon the characteristics of the machine to which they are applied. Snap action limit switches are always used unless the motion is very rapid.

The correct application of limit switches to products and machines often can be simplified by separating the operating requirements into the mechanical and electrical factors that have been discussed. For example, on the mechanical side first determine the characteristic of the motion that is to operate the limit switch, then select the best operating means and transmitting linkage, and so on through the various electrical needs such as contact arrangement and switch rating. However, regardless of the method used, only by carefully integrating the various mechanical and electrical factors can best limit switch operation be achieved.

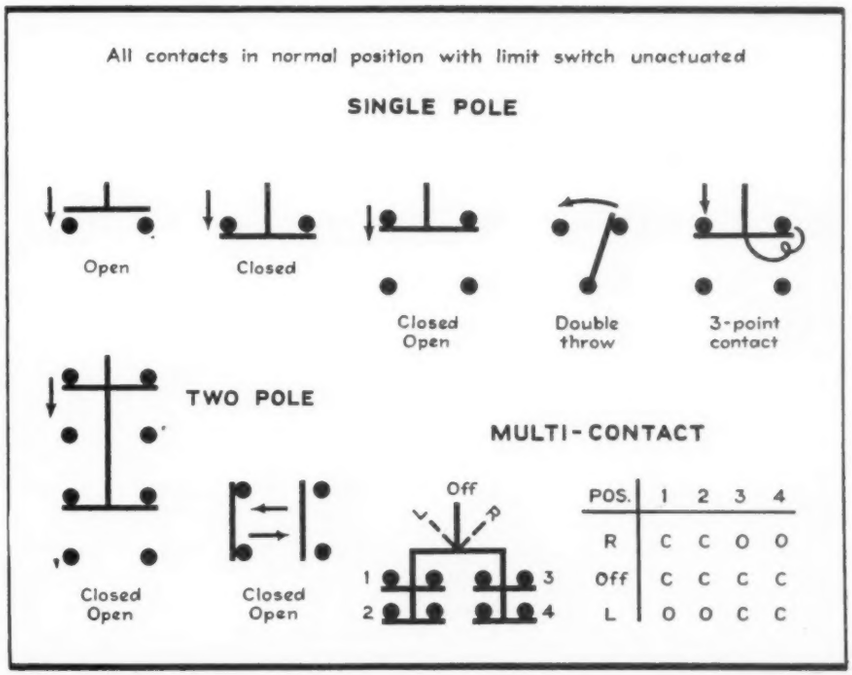


Fig. 6—A few of the many types of contacts that are used for different circuit arrangements. All contacts are shown in unactuated position.

INDUSTRY AND SOCIETIES

RESEARCH—STANDARDS—PATENTS

Simplified Practice Reduces Waste in Industry

Better Design Control Through Simplification Increases Production

INDUSTRY IS CONSTANTLY REDUCING the cost of production and distribution through increased simplification and standardization. The effective use of these weapons has rewarded American industry in its effort to reduce the spread between the prices of raw materials and those of finished products. One method of accomplishing this end can be found in the functions of the Simplified Practices Division of the National Bureau of Standards. This coordinating agency, which is perhaps not so well known as it should be, has a 25-year record of successful voluntary cooperation with industry.

According to Edwin W. Ely, Chief of the Division of Simplified Practice, simplification was yielding savings to industry of well over three hundred million dollars a year before World War II. A manufacturer of self-opening and adjustable die-head chasers found that 80 percent of his business came from 2,000 varieties of 3.6 percent of his total line. The other 96.4 percent representing 53,000 varieties brought in only 20 percent of the business. Elimination of the latter cut his inventory by $225,233 saving him $13,500 a year in interest charges, $12,500 in office payroll, and $10,000 in reduced obsolescence costs.

Beneficial results of simplification can be found in many industries. A well-known manufacturer of electric lamps reduced his variety of lamps from 1,260 to 180 types. Lamp base styles were cut from 179 to 3. By this method he was able to reduce prices of lamps one-half over a period of 12 years, and his sales increased nearly 75 percent in four years. He reduced his transportation and warehousing expenses, increasing the efficiency of his employees, and can now supply the public with better lamps for 25 cents than he could get before he started simplification for $1. A partial list of the reduction in types and varieties in many other fields is presented in the accompanying table.

What is Simplified Practice?

Simplified practice can be considered as a special sub-division of standardization. Standardization is a broad term which applies to numerous features of equipment, methods and procedure. Simplification is a simpler and more restricted term applying particularly to the optimum of existing varieties in a line of manufactured products. Reduction in variety of unnecessary

A Few Results of Simplification

	Varieties		Percent reduction
	Before simplification	After simplification	
Axes, forged	845	199	77
Bags, glassine	124	26	79
Barrels, steel; and drums	66	26	61
Bars, steel, reinforcing	32	11	66
Board, binders'	718	10	99
Bolts, plow	1,500	840	44
Boxes, set-up	1,084	75	93
Brass or bronze valves	11	5	50
Builders' Hardware (items)	6,948	5,130	26
Cartridges, metallic	348	150	57
Cases, flashlight, metal and non-conducting	50	17	66
Chain, welded	1,831	1,214	34
Drums, steel; and barrels	66	26	61
Forged Tools, eye sizes	120	10	91
Grinding wheels	715,200	254,400	64
Insulators, porcelain, one-piece	272	210	23
Iron-body valves, (pressure ratings)	12	3	75
Jacks, screw, bell bottom	78	27	78
Japanned ware, tinware, and galvanized ware	1,154	873	24
Lath, metal (expanded and sheet)	201	57	71
Lining, brake, automobile	100	37	63
Malleable foundry refractories	188	15	92
Nails, cut, small, and cut tacks	428	185	57
Pipe, conductor, eaves trough, and fittings, and ridge rolls	110	79	28
Pipe, wrought-iron and wrought-steel; and valves and fittings pipe sizes	62	48	24
Pipe fittings, (grey cast iron, malleable iron and brass or bronze)	8,566	2,969	65
Rasps and files	661	377	43
Refractories, malleable foundry	188	25	87
Screw, jacks, bell bottom	78	27	78
Shells, loaded paper shot	4,067	262	94
Shovels, spades and scoops	5,136	1,161	77
Solid section steel windows	42,877	2,244	95
Staple vitreous China plumbing fixtures	441	58	87
Steel lockers	65	23	64
Steel reinforcing bars, cross-sectional areas	32	11	66
Steel, sheet	1,630	209	87
Sterling silver flatware	190	61	68
Tanks, expansion; and range boilers	130	13	90
Tanks, storage, hot water	120	14	88
Tools, forged	665	503	24
Turnbuckles	248	115	54
Valves, brass or bronze	11	5	50
Valves, iron-body	12	3	75

types and sizes of manufactured articles constitutes simplification.

The terms "simplification", "simplified practice", "elimination of waste" and "reduction in varieties" have become recognized as belonging to the vocabulary of industrial management. Applications of the principle of simplification can be found in every industry. Many of them have come about through the initiative of individual firms or groups, in addition to those promulgated through the concerted activity of entire industries.

The usual method of applying simplification in an individual plant is to determine the sales volume of each variety of each line of product. This analysis will usually show some kinds and sizes where sales are comparatively small. Further study will show whether or not they can be eliminated without seriously reducing volume of sales or profits of the business. The next step is to study the difference in sizes and qualities of varieties where sales volume is satisfactory. It may then be discovered that orders on many of these items can be satisfied with a fewer number of varieties. That is, some can be eliminated, and others can be redesigned into a composite, with the result that the total number can be reduced. These methods are expected to materially reduce the number of varieties, and thereby bring about substantial economies.

Simplified Practice Division

The Division of Simplified Practice serves as a centralizing and coordinating agency to bring together producers, distributors and users to cooperate in developing best thought and practices in an industry and to promulgate and support recommendations developed by an industry in respect to simplification of its products. Application of simplified practice to any article or commodity may be suggested by anyone concerned in its manufacture, distribution or use. The Division of Simplified Practice does not initiate such project, but acts only upon such suggestions. Most projects are suggested by manufactures although several projects of major importance have been suggested by distributors, and a few by users.

If those best informed regarding the product decide that simplification can be successfully applied, the first step is to prepare a detailed survey to show the percentage of demand for each size, type or variety during the period of at least one year. Such surveys are usually based on figures secured from manufacturers of the product, as they are in the best position to furnish this information. A "Simplified Practice Committee", usually composed of manufacturers, conducts this survey under the auspices of the Division. When the survey has been completed, the Simplified Practice Committee formulates a simplified list of stock items. The Division then arranges a general conference to which representatives of all interested parties are invited. Since the start of the War, however, this has been done by letter referendum and a tabulation of results.

Proposed Simplified Practice Recommendation For Thicknesses of Carbon Steel Plates

When ordering to inches (in.)	When ordering to weights per sq. ft. (lb.)	When ordering to inches (in.)	When ordering to weights per sq.ft. (lb.)
3/16	7.65	1	40.80
7/32	8.925	1- 1/16	43.35
1/4	10.20	1- 1/8	45.90
9/32	11.475	1- 3/16	48.45
5/16	12.75	1- 1/4	51.00
11/32	14.025	1- 5/16	53.55
3/8	15.30	1- 3/8	56.10
13/32	16.575	1- 7/16	58.65
7/16	17.85	1- 1/2	61.20
15/32	19.125	1- 9/16	63.75
1/2	20.40	1- 5/8	66.30
9/16	22.95	1-11/16	68.85
5/8	25.50	1- 3/4	71.40
11/16	28.05	1-13/16	73.95
3/4	30.60	1- 7/8	76.50
13/16	33.15	1-15/16	79.05
7/8	35.70	2	81.60
15/16	38.25		

Plates over 2 inches to 6 inches thick: In increments of 1/8 in.
Plates over 6 inches thick: In increments of 1/4 in.

The Division then transmits to all concerned a detailed report of the general conference, including the simplified list agreed upon. The report includes an acceptance blank with the request that it be signed and returned to the Division. When the volume of acceptance is sufficient to indicate initial success, the Department of Commerce endorses the program and publishes the recommendation including in the published booklet a list of acceptors. The Division thereafter cooperates with a standing committee appointed by the industries concerned, in conducting periodic surveys to determine the degree of adherence and to maintain and extend support of the recommendation and to secure data for revision.

It has been the experience of the Simplified Practice Division that when an initial simplyfying program is started in any one industry, it is not unusual to find that 20 percent of the variety satisfies 80 percent of the demand. An extreme case which illustrates this point was the simplification program in the hacksaw blade industry in 1928. The simplified practice recommendation which was promulgated by the general industry conference called by the Division of Simplified Practice was limited to standard tungsten and carbon blades. It was estimated that the simplified list of sizes represented an elimination of approximately 75 percent of existing catalog sizes.

A recently adopted voluntary simplified practice recommendation that should have far-reaching influence on many different industries is that covering hot rolled carbon steel structural shapes. Although essentially the same as the limitation orders of the War Production Board in this field during the war, this recommendation was proposed by the Technical Committee on Carbon Steel Plate and Structural Shapes of the American Iron and Steel Institute. This recommendation was accepted in February of this year and if widely adopted, should result in an estimated 48 percent reduction in variety. Among the benefits expected to be derived from the general adoption of this recommendation are increased production through less frequent roll changes in the mills; reduction in the inventories of fabricators, warehouses, and manufacturers; and improved service to the ultimate consumer. Some idea of the widespread application of this program can be gained by examining the 19 tables in the recommendation, which cover the nominal sizes and weights per linear foot of wide-flange sections, light beams, stanchions, joists, standard beams, H-beams, wide-flange bearing piles, channels and tees, with angles being shown in thickness. Sections and angles used in car-building and shipbuilding are also included. The recommendation is expected to have greatest application in the construction of bridges, buildings, ships, railroad rolling stock, and other constructional purposes.

The same committee of the American Iron and Steel Institute which recommended the carbon steel structural shapes program has recently developed another program covering thicknesses of carbon steel plates. The recommendation has recently been submitted to producers, distributors and users by the Division of Simplified Practice. Enthusiastic reception of this recommendation is predicted by all concerns, especially in view of the recently adopted bar-size shapes recommendations which has already resulted in an actual 20 percent reduction in variety.

As of July 1946, more than 200 simplified practice recommendations have been promulgated, many of which are under revision. Some of these recommendations and the number of varieties and the percentage of reduction in variety are pre-

sented in the accompanying table. In addition new simplified practice recommendations are being developed for several dozen different commodities such as asphalt tile, carbon steel plates (thicknesses), fencing, staples and nails, and steel valves.

One question that has come up in connection with simlification programs is that of possible anti-trust violations. The Simplified Practice Division points out that industry need have no fear on that score, since a ruling of the attorney general in 1940 specifically pointed out that simplification and standardization procedures do not in any way constitute violations.

National Scale

First application of simplification on a national scale was during World War I. The Conservation Division of the War Industries Board took mandatory action to stop non-essential uses of labor, capital, materials and equipment in all industries. Application of such restricted measures brought substantial savings and increased effectiveness of operation. Many industries wished to continue these practices under peacetime conditions. In response to numerous requests and suggestions the Hoover Committee of the American Engineering Council brought out its now famous "Waste in Industry" report.

On January 12, 1921, Mr. Hoover named 15 engineers as the Committee on Elimination of Waste in Industry. Within less than five months the Committee completed an analysis of waste in six typical branches of industry and presented a summary of its findings to the American Engineering Council (this report was published as a book by the McGraw-Hill Book Company). One of the most important statements in this report reads: "The defective control of design results in a major waste, since it prevents standardization of products." The word "standardization" was used then for lack of the more modern term "simplification."

As a result of enthusiastic reception of the report, which pointed out that a national coordinating body was needed to actively pursue the question of reducing the avoidable waste which is caused by an over-abundance of variety, Herbert Hoover who was then Secretary of Commerce, established the Division of Simplified Practice as a part of the Commerce Secretary's Office in 1921. Direction of the Division of Simplified Practice since 1923 has been under Mr. Edwin C. Ely, who was appointed to the position by the then secretary of commerce, Herbert Hoover. Mr. Ely had come to Mr. Hoover's attention through the former's work as an industrial marketing expert.

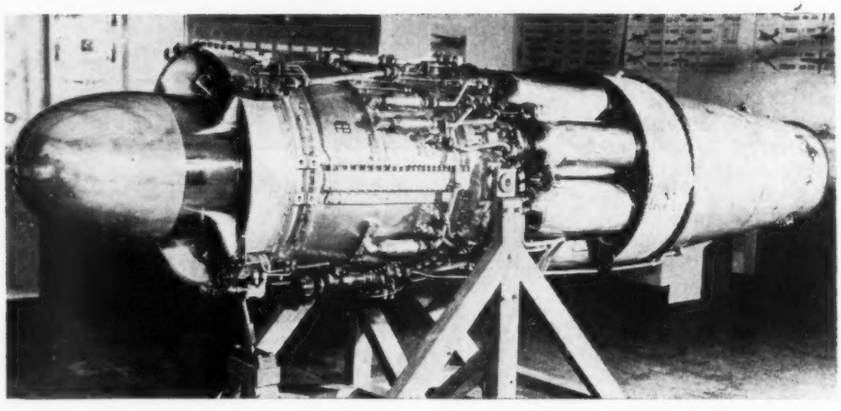
Future Applications

It seems highly probable that there will be a strong trend towards further simplification of every kind of commercial form. A start has been made on bank checks, invoices and warehouse forms, but these represent only a small fraction of the possibilities. Another probable trend will be toward simplification of methods and processes of performing various functions and operations, both mechanical and clerical.

Perhaps the most important trend lies in the general field of distribution. Certain specific opportunities are obvious, as for example in the design and use of containers. Simplified practice recommendations are already in effect covering such items as glass bottles and jars for a few commodities, certain types of barrels and drums, packaging of bolts and other small articles. In "secondary" containers, those in which a quantity of primary containers are packed, the field is virtually untouched. Many products require a third container for shipment, carrying a certain number of secondary containers. The same situation applies to shipping containers, and in addition to the usual advantages of simplification, a further advantage can be gained through reduction in variety of packing and storing methods for shipment in freight cars, trucks and transportation equipment.

Container simplification is closely related to simplification of equipment for materials handling. Opportunities in this field are almost unlimited, since the only simplified practice recommendation so far covers dimensions of skid platforms. Both containers and materials handling equipment must necessarily be studied in their relation to transportation equipment. Here again proponents of simplification claim a host of indirect as well as direct benefits.

Torpedo-Shaped Jet Engine Developed



SHAPED LIKE A STREAMLINED TORPEDO, a new axial flow turbo jet engine has been developed by the General Electric Company. Sustained high speed is possible for planes powered by the new jet, since these engines function most economically when running at nearly full throttle. This means that the cruising speed of an axial flow jet engine is practically top speed.

Known in the Army Air Forces as the J-35, and industrially as the TG-180, the new axial flow jet is more powerful at high speeds than any conventional engine in the air today, and marks definite improvements in aerodynamic design and fuel consumption. These characteristics have resulted in both civilian and military planes being designed to use the new engine at speeds well in excess of 500 miles an hour, where the efficiency of propellers begins to decline sharply.

The new engine is long and light in comparison with reciprocating engines. The frontal area of the axial flow jet is far less than for any reciprocating engine now in use on large planes. This reduces air drag. In addition, the engine will fit more snugly into the wings of a big civilian transport or bomber than any powerful reciprocating engine.

The engine operates as follows: air whips into the relatively small diameter flow compressor. Through multi-stages the air is compressed and then forced almost in direct line into combustion chambers. There fuel is added, usually kerosene. It burns intensely, raising the volume of the gases, which then expand through the buckets of a turbine and on out the jet exhaust. Release of these gases at high velocity creates the reactive thrust which drives the plane forward.

The turbine, rotating rapidly under pressure of gases over 1,000 deg. F. is connected by a shaft with the compressor motor, making only one moving part.

"Standard Grays" Selected For Industrial Finishes

"STANDARD GRAYS" have been selected jointly by Westinghouse and General Electric to achieve color harmony for separate products grouped together, or for two-tone treatment of a single product.

As industry is becoming more conscious of the need for better appearance of shop equipment and of the psychological effect of color in respect to the health, safety and performance of the worker, "color engineering" is rapidly growing in importance.

These grays, identified by the Munsell-Spectrophotometer system, will be applied and tested under all conditions of production, application and durability. It is expected that much of the confusion now existing will be eliminated by this standardization.

WASHINGTON NOTES

Congressional Accomplishments

Bills of national importance, some of which have been debated for more than a year, were shelved or sent back to committee for "consideration," by the 79th Congress, which amounted to the same thing as killing these measures. It is hoped by many that Congressmen will regain enough energy during its six-month vacation to promptly reconsider some of these vital measures when the Congress reconvenes next January, for its 80th session.

Federal Support of Research—This legislation, the progress of which has been reported in this column in the past year, has proved one of the biggest jokers in the 79th Congress. Like all other questions of public welfare everybody agrees that some sort of Federal science legislation would be a good thing, but nobody is willing to do anything about it. After the basic issues involved caused a split in the scientific world as well as in Congress, a "compromise" bill, the Kilgore-Magnuson measure, was finally passed by the Senate and sent to the House. An opposing bill sponsored by Rep. Mills and embodying the views of a large section of the engineering profession, also lay waiting the pleasure of the House. With true statesmanship, both measures were referred to the House Interstate and Foreign Committee, where not only was nothing done about these bills but Committee spokesmen freely admitted that "no action was contemplated in this session." So much for Federal science legislation.

Atomic Energy—In this field Congress proved itself a little more decisive, perhaps because the venerable legislators feel that atomic bombs will not wait six months before exploding.

After some disagreement between the Senate and House a joint Congressional Committee worked out a compromise measure. A controversy had arisen regarding military representation on the five-man Atomic Energy Commission proposed in the McMahon bill. The compromise assured "representation" on the Commission by a military liaison officer who would also be director of the Commission's Military Division. According to the McMahon measure the all-civilian five-man commission would have complete control over all domestic atomic energy matters.

An interesting sidelight of the atomic energy bill is the opposition on the part of some sections of industry to the patent provisions of the measure. It is felt that the definition of atomic energy as outlined in the bill is much too broad, thus enabling the Commission to conceivably control practically all forms of energy now in use. They also object to the sections on control of source materials, production of fissionable materials, and government ownership of all fissionable materials. They feel that the language should be changed to provide for private acquisition, production and use of these materials and for adequate licensing provisions by the Commission. In this connection, it is felt that there is a possibility of unjust discrimination against applicants for licenses on the part of the Commission.

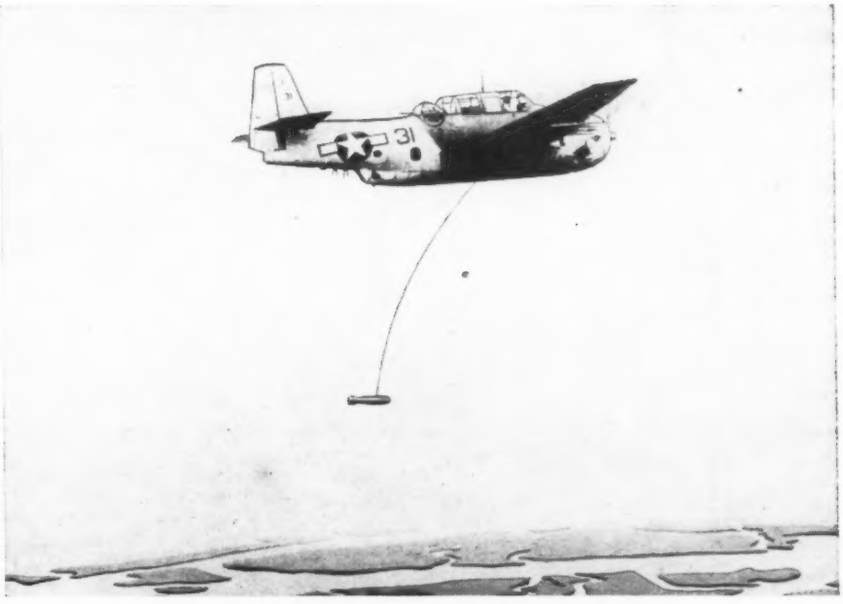
The McMahon bill provides that the Commission is to be the exclusive owner of all facilities for the production of fissionable material other than facilities used in certain fields of research. Industry feels that this section should be amended to allow ownership under license. It is felt that the bill allows the Commission to overstep its intended authority in this respect, since it is possible to control facilities without owning them.

Patent Legislation — Five patent bills worthy of mention were passed by the 79th Congress. The Lanham trademark bill H. R. 1654, passed in July, does not take effect for one year. This bill, a long time industry objective performs a much-needed service by recodifying all federal laws relating to trademarks. This in effect gives trademarks the same status as patents and will serve to clear up present confusion in the courts concerning trademark litigation. Another bill, H. R. 3424, extends the time for renewal of trademarks which were applied for during the war. This bill also makes it possible for those who registered trademarks in this country during the war, and were not able to do the same in other countries, to establish trademarks abroad. This, however, can only be done after the foreign country passes reciprocal legislation.

The other three patent bills were made into law only in the very last days of the 79th Congress. Passage of these measures, H. R. 4080, H. R. 5223 and H. R. 5311, came after considerable public pressure.

H. R. 4080 would attempt to speed up patent office procedure, now badly behind in schedule, by providing for temporary increase in number of Appeals personnel, to be drawn from patent examiners.

An extremely important bill was an-



Exploring for Oil by Air

RELEASED FROM WAR DUTY as a U-boat spotter, the "flying eye," or airborne magnetometer, is now being used for its originally-intended purpose—surveying for oil deposits. This latest wrinkle in geophysics was just being developed by the Gulf Oil Corporation when the war came along. The Navy, Columbia University and Bell Telephone Laboratories perfected it as a submarine detector. Towed by an airplane at the end of a long cable, the magnetometer was adjusted to signal a disturbance in the intensity of the earth's magnetic field caused by the steel hull of a submarine.

When an airplane tows the "flying eye" across land or shallow water, a continuous record of fluctuations in the earth's magnetic field is made. An increase of field intensity can indicate either a deposit of iron ore or the likelihood of oil. The latter can be explained by the bulging up of bedrock, which is more magnetic than sedimentary rock, to form an arch near the surface. Such an arch may contain an oil pool.

The "flying eye" is the only means of magnetic mapping over areas where erratic surface magnetic influences make ground readings unusable. The present instrument is electronically operated and rides in a bomb-like casing trailed beneath the plane to eliminate magnetic interference.

other Boykin measure, H. R. 5223. This measure has several objectives: It provides for reciprocal foreign patent legislation, similar to the Lanham trademark bill. It would allow within all countries passing similar legislation, patents to become retroactive to date of original filing during the war. This bill also extends the life of all domestic patents applied for during the war for a period of one year. It should be kept in mind that this bill is operative in the foreign field only on a reciprocal basis.

The fifth bill passed has aroused some controversy. This is the Henry measure, H. R. 5311, the only patent bill, outside of the Lanham trademark measures, which has permanent aspects. This bill provides that damages in patent suits be ascertained on the basis of compensation for infringement.

Following are just a few of the patent bills on which no action was taken:

H. R. 2631, Rep. Boykin, would make a patent effective for no more than twenty years from the date of application. This is somewhat different than current practice, which limits the patent life to seventeen years from the date of approval. This would have the effect of preventing much unnecessary patent litigation, since unethical "patent jumpers" could not count on the period in which the patent office is considering validity of the patent as an opportunity for a "free ride."

H. R. 3756, Rep. Boykin, which would require the recording in the Patent Office of agreements made by private parties or companies relating to licensing of patents, as passed to House and died a natural death in the Senate Patents Committee. (It should be noted that all bills pending at the time Congress adjourns, automatically become void and must be reintroduced by the next Congress).

H. R. 3757, Rep. Boykin, which has met the same fate as 3756, provides for the public registration of patents available for licensing. It is felt that this bill will aid the inventor who is not familiar with markets, and will give the manufactures an opportunity to see what is being done by the small inventor.

Two other controversial bills were introduced in the House during this session; hearings were held but no action was taken. These were: H. R. 5940, Rep. Lanham, which would make government owned patents freely available to the public. Still more controversial was the Voorhies bill, H. R. 3462, which was an anti-trust measure.

Rubber Note—Final section of the inter-agency rubber advisory committee report on what should be done with the nation's war-built synthetic rubber plants includes creation of a permanent federal rubber policy agency to over-see the whole problem and a combination of subsidies and product specifications to insure continuation of subsidies and product specifications to insure continuation of large scale synthetic rubber production as a permanent national policy.

Signal Corps Trailer Chassis Has Torsion Bar Suspension

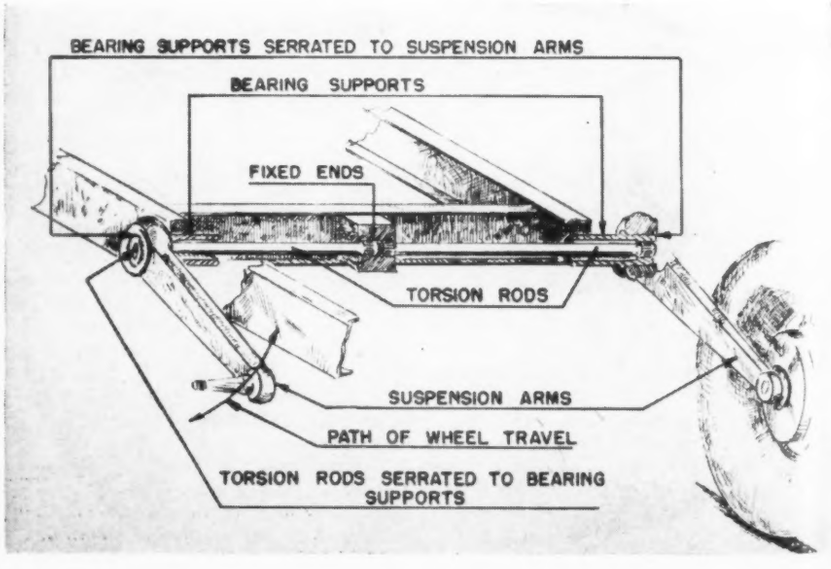
A TORSION bar suspension system for use in equipment trailers has been perfected by the Signal Corps Engineering Laboratories, Bradley Beach, N. J. It consists essentially of a suspension arm attached on one end to the spindle of a wheel and on the other to a torsion bar fixed to the frame of the vehicle. The torsion bar carries the load and absorbs the energy of road shock transmitted by the oscillating suspension arm as the wheel travels over road obstacles. The springing action is produced by the twisting of the torsion bar, which is fixed to a block on a frame cross-member at one end serrated to the bearing supports in the suspension arm at the other end. The torsion bar spring is capable of absorbing more energy per pound of spring weight than the leaf, volute, or helical steel spring.

Although engineers have long recognized the merits of the torsion bar spring, as evidenced by the number of foreign and domestic patents issued on its application, it was not until World War II that the system was employed to any extent. The Germans used it in place of the more conventional coil or leaf spring in their "Volkswagen" which was converted to a military vehicle during the war, and the Japanese employed it in the suspension systems of their field guns. American use was made of it in the Pershing tank, which was carried by torsion bar springs in a system which permitted independent action of the track wheels, enabling the tank to crawl over obstacles instead of having the suspension system lift the tremendous weight of the tank.

The absence of an axle under the trailer shown in the photograph has been used to advantage in this recent Signal Corps design. The wheels are designed so that they may be retracted by the gear-driven rotation of the anchor for the fixed ends of the torsion bars. This permits the trailer frame to be quickly lowered to the ground and leveled by short sturdy jacks, thus increasing stability and lowering the silhouette during operation.

Tests of these trailers have been highly successful and have shown the merits of the torsion bar spring and its adaptability to suspension systems for trailers. Impetus has been given to further improvement and development leading to vehicles of less weight, less maintenance, and greatly increased performance and utility.

Mechanical treatment and workmanship have a very marked effect on the strength and life of torsion bars. The bars are



finish ground after machining to eliminate nicks and scratches. After they have been heat-treated, the bars are shot-peened. The bars are then "preset" by cold twisting beyond the limit of the angle of twist to be encountered during service, an operation which increases their yield strength.

NACA Wind Tunnel For Supersonic Research

PROBLEMS OF FLIGHT beyond the speed of sound are being systematically attacked by the National Advisory Committee for Aeronautics in its new supersonic wind tunnel—the largest in the United States (shown in photograph on following page).

The 1500-mile-per-hour wind tunnel, located at the Ames Aeronautical Laboratory of the NACA at Moffett Field, California, is designed to operate exclusively above the present limit of human flight imposed by the same phenomenon, the velocity of sound (approximately 760 miles per hour). In the range of speeds above this natural barrier, until recently penetrated only by pilotless projectiles, tests will be conducted upon models of guided missiles and jet- and rocket-propelled aircraft. From this fundamental research will be obtained a knowledge of the design requirements for stable and controllable flight at the tremendous speeds made possible by recently-perfected systems of propulsion.

Accurately-made steel models are mounted in the three-square foot test section of the new supersonic tunnel. Air is forced through this constricted channel at as much as twice the speed of sound, simulating the conditions encountered by a supersonic aircraft. Power is provided by electric motors totalling 10,000 horsepower driving four three-stage centrifugal compressors which rotate at a constant speed of 5350 revolutions per minute. The heat generated in the compression of the air is removed by passing the air through large water-cooled radiators provided in

Foreign Reports

. . . . from McGraw-Hill World News

12 Nations at London Conference Agree on Patent Pool

The twelve-nation conference on the disposition of more than 100,000 formerly German-owned patents registered in various United Nations has agreed on a plan to make such patents freely available to nationals of all countries signatory to the agreement.

In the opinion of experts attending the conference, this agreement is a shattering blow to Germans' known plans to recover their former influence in key industries throughout the world. The agreement is also a major step toward the United States Government's objectives in the field of world trade policy.

If the various countries that confiscated German patents during the war had decided to hold the patents exclusively for their own nationals, no country could have permitted imports of any products likely to infringe German patents. Since the United States has some 30,000 such patents, France has 50,000 and Belgium, the Netherlands and other countries have several thousand each, the number of products barred from trade would have been very large.

Under the agreement, however, German-owned patents which the signatories have already granted or licensed to their nationals do not fall within the agreement—which means that enemy patents are frozen as of August 1 and from then on before signatories of the accord (United States, Great Britain, and the Netherlands) agree not to grant or license any more patents exclusively to their nationals; the eight additional signatories of the resolution, provisionally agree to the same until such time as they decide definitely not to adhere to the accord.

The conference gave approval to the program in operation for publishing information on German technology and suggested that technical personnel of all countries at the conference be utilized in the preparation of German industrial reports.

The text of the accord indicates that the American delegation, headed by Casper Ooms, Patent Commissioner, has been almost 100 percent successful in getting the conference to adopt its views. The United States had already made former German patents freely available to American concerns and the new agreement is in effect an international extension of that policy.

International Standards Meetings Slated for London in October

Meetings to draw up plans for establishing a new international standards organization were held in Paris at the Palais d'Orsay on July 11, 12 and 13, with 18 delegates from nine nations in attendance (see story on page 144 of August Product Engineering). As a result of the meetings a full conference of representatives of the national standards associations of 28 or more countries will be held in London, starting October 10, to get the new organization formally under way.

The delegates to the Paris meetings were the directors of the United Nations Standardizing Coordinating Committee (UNSCC) and the pre-war International Standardizing Association (ISA). Each group as a formality held separate meetings, though the personnel of each was largely identical. The meetings were chaired respectively by James G. Morrow, Chairman of the Canadian Standards Association and Chairman of the Executive Committee of UNSCC, and A. E. Lhoste, Director General of the *Association Francaise de Normalization* and newly elected President of the ISA.

All proposals at the meetings were of a tentative nature, subject to discussion and ratification by the London conference. Chief agreement came on the following points:

1. To merge the two international organizations into one, probably to be called by the same name as the old International Standardizing Association.

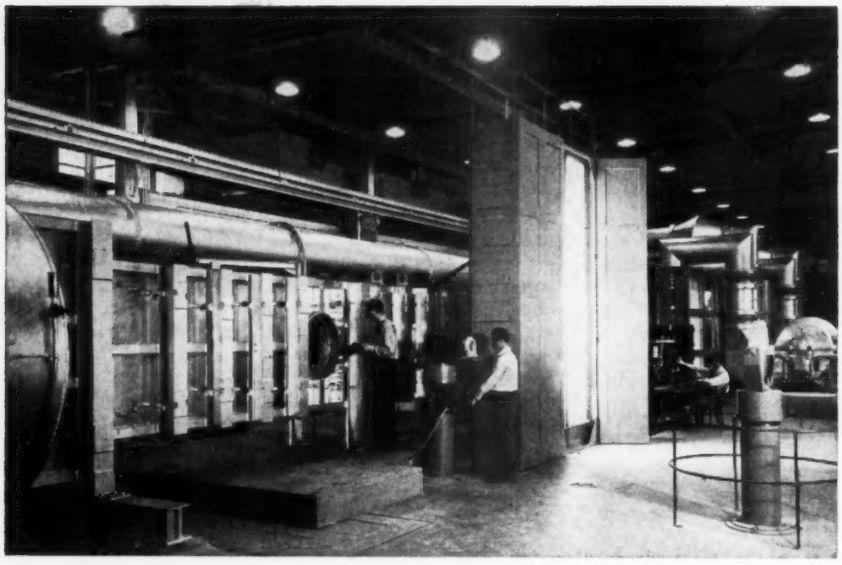
2. To establish an international secretariat in Europe, but with an American preferably at the head of it. Location of the secretariat probably will be in Paris.

3. To refuse admission in the new organization to Germany, Japan and, at the Russians' request, Spain. But other nations not members of the ISA before the war and now members of UNSCC will be invited to the London conference, and any other nations with national standards organizations will be invited to join when the new group gets established.

4. To encourage the new organization to take up where the ISA left off at the outbreak of the war in its work of promulgating and publicizing international standards. Also various delegations suggested new fields to be studied for the application of international standards, such as the French proposals for worldwide norms in the machine-tool, building and automobile industries, and the British suggestion for an international standard for the chemical compositions of steels.

Among the delegates—standards officials from Canada, Denmark, France, Great Britain, Italy, the Netherlands, Switzerland, the U. S., the U.S.S.R., and the UNSCC London office—were Dr. P. G. Agnew, chairman of the American Standards Association, and Dr. E. C. Crittendon, President of the American Electro-technical Commission.

The new ISA, when it is formed in London, will be able to make use of a large fund of experience and technical information accumulated in the minds and files of the old ISA's secretariat during the years 1930-1939 when it was active. In addition there remain, scattered among the national standards organizations of various countries, the data accumulated by the 47 technical committees of the ISA, and their numerous subcommittees.



the wind tunnel circuit.

Variation of the scale of flight is achieved by changing the pressure inside the tunnel from a near vacuum up to almost three times normal atmospheric pressure. Sensitive regulators maintain the pressure automatically at the desired value. In addition, the humidity of the air in the tunnel can be accurately controlled. Air dryers permit reduction of moisture content inside the tunnel to as little as one percent of that of normal atmospheric air.

Missile or aircraft models are supported in the stream of air on a slender boom extending from a balance which weighs the aerodynamic forces. Lift, drag, and pitching moment acting on the model are transmitted to springs whose deflections are measured by electric strain gages. Simultaneously a sensitive optical apparatus permits the flow of air past the model to be observed and photographed. Details of the flow pattern visualized by this "schlieren" method provide a valuable aid in interpreting the numerical balance.

Even greater speeds, up to the present foreseeable limits for guided missiles and aircraft, will be reached in another supersonic wind tunnel now nearing completion at the same laboratory. Complementing the present apparatus, it will extend the available range of supersonic testing speeds to an extreme of 3.6 times that of sound for short periods of time. Having a test section identical with the electrically-driven tunnel to permit interchange of models, this "blowdown" tunnel will operate intermittently from a huge pressure tank. All observations will be made within a period of about ten minutes, in which time the entire supply of high-pressure dry air is exhausted to the atmosphere.

Army Uses Three-Dimensional Photography to Inspect Textiles

THE QUARTERMASTER CORPS has perfected a new use for the Army's three-dimensional photography technique for more accurate inspection of textile materials destined to go into Army clothing and other fabric material.

Ordinary photography has been considered as a possible method of inspection but the photographs, while showing the general characteristics of the cloth, had a tendency either to exaggerate or minimize the degree of seriousness of the defects due to lights and shadows.

Further research into the photographic method led to the use of vectographs which utilize the stereoptician effect to produce a three dimensional picture with depth perception. The experiments with three dimensional pictures disclosed that it was possible to identify the cloth as to type, and also to determine the exact degree of seriousness of the various defects. Vectographs eventually will be used as visual inspection gauges to establish definite standards in all mills producing textiles for the Quartermaster Corps.

The new technique was described at a meeting of the American Association of Textiles Technologists in New York City at 6:30 p.m. April 3, by a representative of the Quartermaster Corps Inspection Branch.

Quartermaster Corps Devises Safety Color Code

THE VALUE of a standard safety color code has been borne out by the experiences of the 26 Quartermaster Corps and Army Service Forces Depots in which such a code has been generally adopted.

Certain types of accidents, resulting in disabling injuries, have been entirely eliminated, while others have been reduced from a frequency of 46.14 to a yearly average of 5.58 since the employment of the safety color code.

Red, green, yellow, white, and black, and combinations thereof, are the colors that were agreed upon for the standard code. Red is the basic color for the identification of fire protection equipment and apparatus, danger, and stop signals. Green is the basic color designating safety, the location of first aid equipment, first aid dispensaries, starting buttons, the "go" for traffic, and all instances where safety is to be designated. Yellow is the color used to designate caution and for making physical hazards more visible. Where local conditions call for a more striking symbol, black and yellow stripes or a checkerboard effect is used. Black, white, or a combination of the two are the two basic colors for designating housekeeping, sanitation and traffic markings.

The basic colors and their combinations have been kept to a minimum to avoid the confusion that would result with too many different signals constantly in the vision. The code was designed so as not to conflict with any already standardized signals or symbols now in use.

MEETINGS

September 16-20
Instrument Society of America—First national instrument conference and exhibit, William Penn Hotel, Pittsburgh, Pa.

September 17
Navy Industrial Association—Annual meeting, Waldorf-Astoria Hotel, New York.

September 30-October 3
American Society of Mechanical Engineers—Fall meeting, Hotel Statler, Boston, Mass.

October 2
Northeastern Wood Utilization Council—Syracuse University, Syracuse, N. Y.

October 3-5
National Electronics Conference—Edgewater Beach Hotel, Chicago, Ill.

October 9-11
Porcelain Enamel Institute—Annual forum, University of Illinois, Urbana, Ill.

October 14-19
Electronic Radio and Television Exposition—Grand Central Palace, New York City.

October 16-19
Electrochemical Society—Fall congress, Royal York Hotel, Toronto, Canada.

October 23-26
National Tool and Die Manufacturers Association—Annual meeting, Congress Hotel, Chicago, Ill.

October 25-26
Society of Rheology—Annual meeting, Hotel Pennsylvania, New York.

RESEARCH NOTES

Engineering Educators Include Research Functions

The recent reorganization of the Society for the Promotion of Engineering Education resulted in formation of a new organization, the American Society for Engineering Education, accompanied by a complete revamping of the constitution of the old organization. Pointing up the relationship between the two principal functions of a modern engineering college—education and research—the new constitution made possible the amalgamation of the S.P.E.E. with the Engineering College Research Association, and broadens the functions of the administrative division of the A.S.E.E.

Announcement of the reorganization came at S.P.E.E.'s annual meeting in June, held at Washington University in St. Louis, Mo. The change came after more than a year of discussion involving definition of the research functions of engineering educational institutions.

The Engineering College Research Association was organized in 1942 with four objectives. First, it was to be an agency which would assist engineering colleges in organizing their facilities for the promotion of engineering research. Second, it was to assist in organizing research facilities to improve processes affecting industry, public works, public health and future conservation and development of natural resources. Its third objective was to serve as a developing and coordinating agency for furthering advanced industrial and scientific studies in the engineering colleges of the United States. And, finally, it would collaborate with other associations and with the Federal Government for maximum utilization and coordination of engineering and scientific facilities of the nation, with a minimum of duplication.

For many years the Committee on Engineering Research of the S.P.E.E. has successfully carried on annual sessions on engineering research and has held several forums and symposiums on the subject. These activities were paralleled in the Land-Grant College Association and a similar group representing the engineering colleges of separate state universities; engineering colleges of the metropolitan district had also maintained some exchange information among their own members.

A joint committee representing all these groups had discussed with the S.P.E.E. Council the possibilities of setting up a more active research body under the sponsorship of S.P.E.E. For legal reasons it was decided that these activities could not be carried on under the S.P.E.E. and it was suggested that a separate organization be set up for the purpose. This resulted in the formation of the Engineering College Research Association.

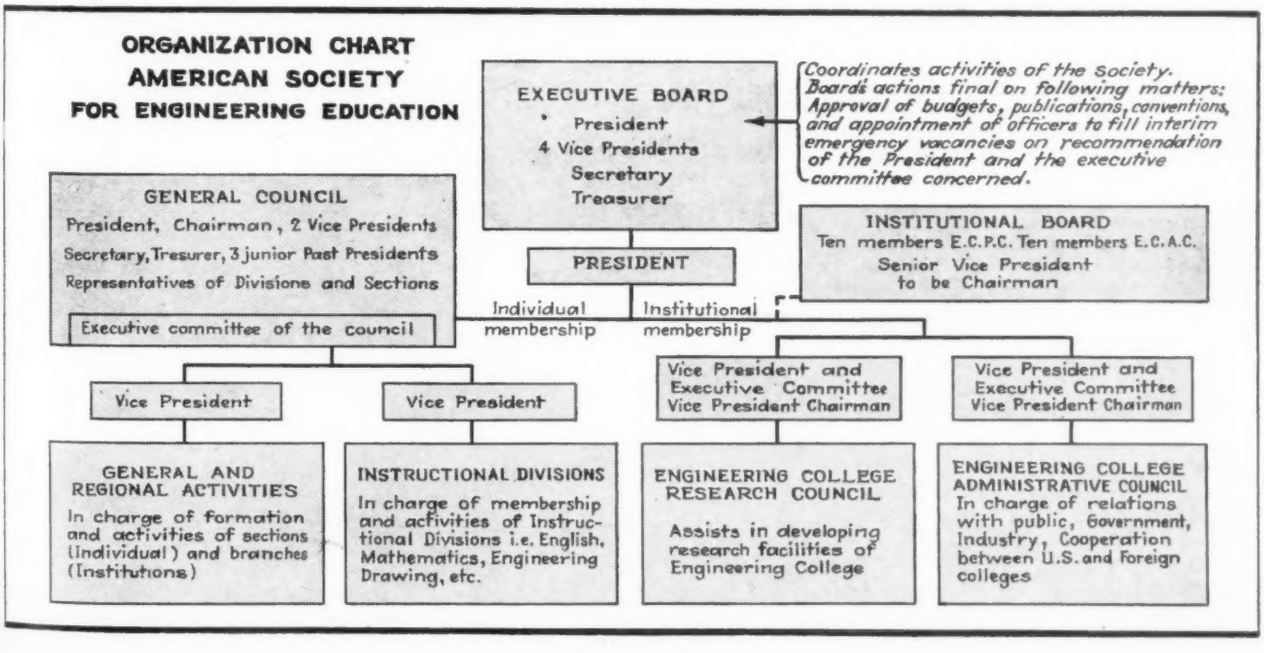
Probably the greatest need that was filled by the Engineering College Research Association was the pressing of matters of great importance before legislative and other federal groups. It was this right to appear before congressional committees and legislative groups that was not permissible under the S.P.E.E. With emergency federal legislation and directives pointed toward establishing controls and allocation of engineering and scientific research, the authority to speak with firmness and decision was most essential to the legislative committee of the Engineering College Research Association.

A word about the problem of the Division of Administrative Officers of the S.P.E.E. is in order at this point. The first specialized activities of this division, accelerated during the war period, were not provided for under the old constitution of the S.P.E.E. Some of these activities were: Provision for subsidies for education and research in scientific and technological fields; the diversion of an adequate supply of surplus war properties to augment equipment of educational institutions; consideration by competent educators of the proposed plan for universal military training; expression of opinion on proposed legislation concerning research and education; evaluation, both for the public and for educators, of the true significance of science and technology as social phenomena. It was felt that functions of the S.P.E.E. did not lend themselves to this type of activity.

The merger proposal, first advanced about eight months ago, came after there had been some evidence that the administrative division of S.P.E.E. had many items more in common with the activities of the Engineering College Research Association than with the parent organization.

From these suggestions came the belief that if the Engineering College Research Association could retain its autonomy and work with the administrative division of S.P.E.E. in a coordinated program, the parent organization as well as the administrative division and the College Research Association would be equally benefited.

The potential strength of the new organization, the American Society for Engineering Education, was realized by many of those attending the St. Louis meeting. The fact that many members of the engineering profession who are not directly concerned with education are members of the engineering educators organization, or at least attended the St. Louis meeting, is especially significant in this respect. The possibility of a broad organization encompassing both "working" engineers and engineering educators is not entirely remote. Such an organization, somewhat similar to the American Medical Association, would give the engineer "education" in the true sense of the word; that is, the formal part of his training as well as "post-school" experience would be guided and his interests


ORGANIZATION CHART
AMERICAN SOCIETY
FOR ENGINEERING EDUCATION
EXECUTIVE BOARD
President
4 Vice Presidents
Secretary
Treasurer
Coordinates activities of the Society. Boards actions final on following matters: Approval of budgets, publications, conventions, and appointment of officers to fill interim emergency vacancies on recommendation of the President and the executive committee concerned.
GENERAL COUNCIL
President, Chairman, 2 Vice Presidents
Secretary, Tresurer, 3 junior Past Presidents
Representatives of Divisions and Sections
Executive committee of the council
PRESIDENT
INSTITUTIONAL BOARD
Ten members E.C.P.C. Ten members E.C.A.C.
Senior Vice President to be Chairman
Individual membership
Institutional membership
Vice President
Vice President
Vice President and Executive Committee Vice President Chairman
Vice President and Executive Committee Vice President Chairman
GENERAL AND REGIONAL ACTIVITIES
In charge of formation and activities of sections (Individual) and branches (Institutions)
INSTRUCTIONAL DIVISIONS
In charge of membership and activities of Instructional Divisions i.e. English, Mathematics, Engineering Drawing, etc.
ENGINEERING COLLEGE RESEARCH COUNCIL
Assists in developing research facilities of Engineering College
ENGINEERING COLLEGE ADMINISTRATIVE COUNCIL
In charge of relations with public, Government, Industry, Cooperation between U.S. and Foreign colleges

watched over. The latter quality would make this type of organization a powerful force among the engineering professions. That this potentiality has been recognized is indicated by the fact that all the major engineering societies had prominent members present at the St. Louis meeting.

The administrative set-up of the new organization is reflected in the kind of officers who will run the new association. Serving under the new president, H. O. Croft of the University of Iowa, will be four vice presidents. Two vice presidents will administer general and regional activities as well as the instructional division. Two new vice presidents, however, reflect the amalgamation that has taken place. There will be one vice president for the Engineering College Research Council and the other for Engineering College Administrative Council activities. The latter two officers would look after the interests of the two groups who previously had felt that their activities would not be carried on within the framework of the now-defunct S.P.E.E.

Navy Sponsors Guided Missile Research

An intensive research and development program on guided missiles designed to operate in the supersonic speed range is being carried out for the Bureau of Ordnance by the Applied Physics Laboratory of Johns Hopkins University at Silver Spring, Md. the Navy Department revealed in presenting the Naval Ordnance Development Award to the University.

Basic data necessary to meet problems arising in the relatively unexplored field of supersonic aerodynamics is being gathered by Johns Hopkins University and associated industrial and university groups under special research contracts with the Bureau of Ordnance.

Fundamental research on basic theories, measurements and instrumentation is expected to contribute to the general fund of knowledge concerning guided missiles in this country, and to have commercial as well as military application.

The Applied Physics Laboratory at Silver Spring, which has been engaged in the guided missile research and development program since January, 1945, was presented the Naval Ordnance Development Award for outstanding research and development on the radio proximity fuze, gun directors Marks 57 and 61, a torpedo explorer and guided missiles.

Insulation Research Center

Plans for a new research center in which expanded development work will be carried on in the fields of building materials and industrial insulations were announced by Johns-Manville Corp. It is the first project announced in a company wide expansion program in the United States, Canada and abroad which calls for the expenditure of approximately $40,000,000. The research center, the first unit of which is already under construction, is planned ultimately to be a group of six buildings located near Bound Brook, N. J., across the Raritan River from the Johns-Manville plant at Manville, N. J. Dr. C. F. Rassweiler, Vice President and Director of Research in describing the research center, said that the first unit, in addition to research laboratory facilities, will also include 10 pilot plants.

Natural Science Fellowships

The National Research Council is ready to receive nominations and applications for the predoctoral fellowships in the mathematical, physical, and biological sciences which it is administering under a grant from the Rockefeller Foundation. These fellowships are intended to assist young men and women, whose graduate study has been prevented or interrupted by the war, to complete their work for the doctorate. It is hoped that these fellowships will do much to accelerate the recovery of the scientific vigor and competence of the country which is so seriously threatened by the loss of almost two graduate school generations of scientifically trained men and women.

This program will be administered by a Committee on Predoctoral Fellowships of the National Research Council whose members are Henry A. Barton, Charles W. Bray, Detley W. Bronk, Luther P. Eisenhart, Rose G. Harrison (chairman, National Research Council, ex officio), W. A. Noyes, Jr., John T. Tate, chairman, and Enid Hannaford, secretary.

Information concerning the fellowships and nomination-application blanks may be obtained from the Secretary, Committee on Predoctoral Fellowships, National Research Council, 2101 Constitution Ave., N. W., Washington 25, D. C.

Standard Oil Research

The Standard Oil Company of Ohio plans to construct a laboratory in the Warrensville Heights section of Cleveland, wherein the research activities of the company will be consolidated. Cost of the project is expected to be in the neighborhood of $1,500,000 with construction to start when materials become available.

Research by the company is carried on now in conjunction with Western Reserve University and at the company's refineries in Cleveland. The University and the company will continue to cooperate in research when the new laboratory is finished.

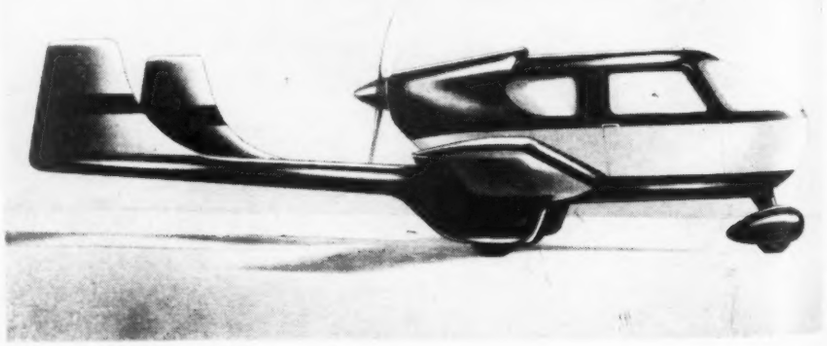
All-Metal Personal Plane

DESIGNED FOR OPERATING ECONOMY, a new 4-place, pusher-type, all-metal monoplane known as the Wheelair 111-A marks the entry of Puget Pacific Planes, Inc., of Tacoma, Washington, into the aircraft manufacturing field. Having a maximum speed of 135 m.p.h., a cruising speed of 120 m.p.h., (75 percent power), and a landing speed of 55 m.p.h., the airplane features automobile-type, fully upholstered seats, with provision for pilot, three passengers and 160 pounds of baggage. Both front and rear "coach type" seats are divided so that each can fold forward independently of the other.

A feature of the Wheelair 111-A is the good vision offered by the pusher design and forward-placed cabin. A steerable nose wheel offers easy taxiing and parking, and pedal-controlled brakes and tricycle landing gear facilitate short, smooth landings. Large area flaps allow slow landings and accurate glide-path control.

The pusher design is claimed to eliminate many faults of standard type airplanes, such as excessive vibration, noise and exhaust and gasoline fumes. The twin tail booms provide positive protection from the propeller for passengers and onlookers while on the ground.

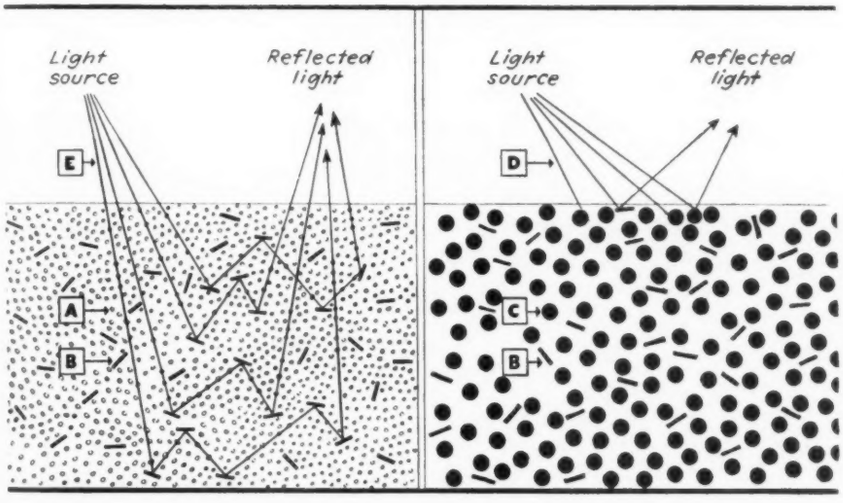
A Lycoming GO-290-AP four-cylinder air-cooled engine is used as standard equipment. A geared, horizontally opposed engine, it develops 170 hp. for takeoff, and has a normal rating of 160 hp. Gross weight of the Wheelair 111-A is 2,500 pounds; weight empty is 1,350 pounds. The wing loading is 13.9 lb. per sq. ft. and allows positive control while taxiing in high winds and avoids ballooning.



New Automobile Finish Developed by Du Pont

A NEW AUTOMOTIVE FINISH—"Duco" Metalli-Chrome nitrocellulose lacquer—utilizes new pigment materials. A rich, deep-glowing appearance results from the high degree of translucency of the lacquer film. Light penetrates the film and is reflected to the eye from underneath instead of rebounding from the outer surface as it does when it strikes a conventional coating. The glowing effect is enhanced by small particles of aluminium flake which act as tiny mirrors, diffusing and reflecting light within the film. Eleven 1946 automobile models employ the new lacquer.

Two developments are responsible for the Metalli-Chromes: Methods have been developed for removing infinitesimally small pigment particles, still wet, from their mother solutions and for transferring them in their original finely-divided state without drying or grinding, directly into a lacquer. The second development was the discovery of a new pigment—ferric hydroxide. Although ferric hydroxide as a chemical material and as an intermediate in the manufacture of iron oxide pigments has been known for centuries, it had never before been used as a pigment.



Simulated cross sections of Metalli-Chrome lacquer (left) and pre-war metallics (right). *A*—A tiny, translucent pigment particle; *B*—Aluminum flake; *C*—Large opaque pigment particle; *D* and *E*—Light rays. Light enters the new films, is diffused and reflected back to the eye instead of being reflected solely from the outer surface.

Azon Bomb Guided By Remote Control

THE ARMY AIR FORCES recently made public the "Azon" bomb. Azon is the standard 1,000 pound demolition which has a "radio brain" attached. This enables the bombardier to sight the missile on his Norden bomb-sight and let it go. Once the bomb is dropped the bombardier continues to guide it in azimuth (right or left of the target) by remote control.

A 1,000,000 candlepower flare on the tail of the Azon is automatically ignited by a fuse after it leaves the plane. Merely by following it with his eye, the bombardier can detect errors in azimuth as small as five or ten feet at an altitude of 15,000 feet. He corrects them by pushing the handle of the control box in the aircraft to right or left.

This successful "guided missile" of the Army Air Forces was first introduced to the Japanese on December 27, 1944, when a three-span steel railway bridge on the rail line between Rangoon and Mandalay was destroyed by the Seventh Bomb Group of the Tenth Air Force. The accuracy of the bomb did much to choke off the free movement of Japanese transportation in Burma. On seven missions, fourteen bridges, vital links in the Japanese supply system, were destroyed by using a total of 154 Azon bombs.

Awards Offered Designers In Lincoln Foundation Program

AN OPPORTUNITY for those engaged in the design, manufacture or construction of any type of machinery or parts, is offered by the James F. Lincoln Arc Welding Foundation, Cleveland, Ohio, in the announcement of their new $200,000 "Design-for-Progress" Award Program.

Three classifications of the program are devoted to machinery. These are, "Functional Machinery," "Industry Machinery," and "Personal Service Machinery."

Eighty-four awards, totalling $46,200 are established for the machinery design and manufacturing fields. Three winners of divisional and classification awards in the three machinery classifications will also be possible recipients of the main awards of $10,000, $7,500 and $5,000, respectively. The principle program award, which may be won by a paper in any of the machinery classifications, is $13,200.

To assure equal opportunity in the "Design-for-Progress Award Program," awards are offered in each of the fifteen major classifications which are: Aircraft, (2 divisions); Automotive, (2 divisions), Containers, (2 divisions); Furniture and Fixtures, (2 divisions); Functional Machinery, (6 divisions); Industry Machinery, (6 divisions); Personal Service Machinery, (6 divisions); Railroad, (2 divisions); Structural Buildings and Bridges, (2 divisions); Structural Houses and Miscellaneous, (2 divisions); Watercraft, (2 divisions); Welderies, (2 divisions); Commercial Welding, (2 divisions); Maintenance, (2 divisions); and Research and Education, (3 divisions).

Complete details of The $200,000 "Design-for-Progress" Award Program, which closes June 1, 1947, may be obtained by writing the Secretary, The James F. Lincoln Arc Welding Foundation, Cleveland 1, Ohio.

New Quarters for A.S.H.V.E.

THE AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS has moved its Research Laboratory to 7218 Euclid Avenue, Cleveland 3, Ohio, to provide adequate research facilities for serving the heating, ventilating and air conditioning industries. The property consists of a substantial dwelling with a large two-story brick auditorium type building attached. Cyril Tasker, Director of Research, is in charge. He is assisted by C. M. Humphreys, Senior Engineer; H. B. Nottage; C. V. Parmelee; Dr. A. D. Brandt, assigned to the Society's Laboratory by the U. S. Public Health Service, and a group of research assistants and technicians.

First Postwar Machine Tool Forum

ATTENDANCE AT THE TENTH ANNUAL Machine Tool Electrification Forum held in Pittsburgh, Pennsylvania under the sponsorship of Westinghouse reached pre-war levels with 232 delegates registered. Represented were 113 companies that produce machine tools, 19 editors of technical magazines, 4 engineering associations and 3 government purchasing commissions.

The theme of the Forum was: Higher quality products in volume and at prices everyone can afford. Papers presented dealt with domestic and foreign markets, the case for standardization, electrical equipment for automatic tools and trends in machine tool wiring methods.

The two-day session was opened by D. W. McGill, Manager of the Westinghouse Machinery Electrification Section, who also acted as chairman.

Illustrated talks were presented by: W. B. Wigton, Cincinnati Planer Company; B. T. Anderson, Sundstrand Machine Tool

Company; R. H. Clark, Warner & Swasey; A. L. Krause, Brown & Sharpe; E. E. Opel, National Automatic Tool Company; R. Griffith, Heald Machine Company; R. W. Moore, L. W. Herchenroeder, H. D. Dorfman, and C. E. Herr, Westinghouse.

SPI Launches Labeling Program

LAUNCHING OF A NATIONWIDE move by member manufacturers to aid consumers in obtaining the greatest possible satisfaction from plastics purchases, has been formally announced by Neil O. Broderson, President of the Society of the Plastics Industry.

Guidance in undertaking this move has been provided by an Informative Labeling Committee of SPI which has had the full cooperation of the material manufacturers.

As a service to manufacturers of plastics articles, SPI has issued a booklet entitled "Informative Labeling Guide", copies of which are now available. This Guide contains a series of basic descriptions of various plastics used in consumer goods.

Industrial Scholarships To Spur Packaging Research

FIVE SCHOLARSHIPS, to be awarded annually in the field of packaging research, and to be known as the "Modern Packaging Magazine Awards," have been announced as accepted by a group of American universities and colleges. Judges of the plan include Dr. L. W. Elder, General Foods Corp.; Dr. E. C. Merrill, United Rexall Drug Co., Boston; Dr. Julian Toulouse, Owens-Illinois, Toledo.

The Modern Packaging scholarships, which will be awarded on the bases of outlines for research projects in any field of packaging, are expected to supplement private research. It is also expected that as a result of these scholarships educational institutions will take more cognizance of packaging problems and may widen technical courses to permit training packaging technicians.

The awards, five in number, amount to $300 each. They are offered initially by Modern Packaging Magazine with the expectation that companies engaged in packaging will utilize this as a precedent to support an academic program that will permanently benefit the 44 packaging industries and their suppliers.

Bearings Identification Guide Compiled by Navy

AN ANTIFRICTION BEARINGS identification code covering more than 50,000 types has been worked out by the Navy's Bureau of Ships. Its sponsors hope that it will be accepted by all the services, by the manufacturers, and by users generally.

The guide has been compiled in the form of two catalogs, one for the numbering system and the other for materials.

Use of these volumes hinges on a master number, in three sections, having a maximum of twelve digits whose fixed positions represent dimensions and features of the bearing.

For example, 111-02502-1510 means the bearing is in group 1, type 11, and has a bore of 25 millimeters (.025 meters), a dimension code 02, a modification of design code of 15, and tolerance fit and lubrication code of 10. The latter three figures refer to data in the tables dealing with dimensions, shields, snap rings, grooves, retainers, tightness of fit, and oil required.

The master number is devised along the lines of the decimal library index and can absorb a 100 percent increase in bearing types. At present the code uses both metric and inch measurements, but it could easily make the shift to all-metric if the country should decide to do so.

Groups referred to by the first digit are nine in all: annular ball bearings, cylindrical roller, journal and needle, pure thrust, aircraft, control and pulley, industrial power transmission ball and roller, tapered roller, general purpose underground, and special purpose.

Management in the antifriction bearing industry voted late in 1945 to put aside its own system until observation shows whether the Navy code is practical for use by the industry. The American Standards Association is circulating the Navy system so as to secure members' comment.

The Navy cites tires, radio tubes, electric light bulbs, steel sheets, bars and tubes, and pipes and fittings, as evidence that common identification is feasible in competitive fields.

DISCUSSIONS AND COMMENTS FROM READERS

International Unification Of Engineering Standards

To the Editor:

I have read with interest the article on "International Unification of Engineering Standards" in the "Industry and Societies" section of the April 1946 issue of PRODUCT ENGINEERING and, as one greatly interested and involved in National and International Standardization, I appreciate the publicity your article has given this effort.

Those who have been in comparatively close contact with the deliberations of the delegates to the three-country conference, understand perfectly that the agreements reached are tentative and are to be considered only as recommendations to the committees on standardization.

Your article, however, principally because of the subject heading, "Agreements Reached in Three Country Conference", may lead readers to the conclusion that the differences between the three countries are all settled and they may edit and issue orders for threaded product or tools and gages for this product accordingly.

I am drawing this matter to your attention to clarify this subject and to help keep it before the public and the committees of the three countries, in the hope that there may be an early and final settlement.

—W. C. MUELLER
Western Electric Company, Chicago, Illinois.

"The Suppression of Patents"

To the Editor:

Both of the readers commenting, on page 502 of the June issue of PRODUCT ENGINEERING, on Mr. Morrow's article are not too well acquainted, in my opinion, with the consuming public's viewpoint.

Mr. Morrow mentions that there are court decisions upholding the inventor's right not to work his patent. Does he have to list them specifically? Cannot Mr. Henry as an Assistant Commissioner find out about those cases?

Why did not Mr. Schramm look up the fluorescent lamp case before he addressed himself to PRODUCT ENGINEERING readers? Few of them do not know the facts of the incandescent lamp in regard to volts, life and lumens, and few also do not know that it is a replacement business and that it is perfectly possible to get lamps of longer or shorter life without sacrificing any other qualities. I would like to call his attention to the Japanese bulbs that flooded the market at one time and pulled down the cost of our domestic bulbs. They were just as bright, if not brighter. They drew the same current, but they did not last as long. But they were economically better to use until our domestic product came down in price.

I know of one case of partial suppression, and it has to do with flourescent lights. They are more efficient than incandescent lights, and large factories were made aware of this through the trade journals. Their connected load was at a low rate (otherwise they would generate their own electricity), and so the central stations did not care if they installed a few lights of better efficiency, as it was a small percentage of their demand anyway. They did not want the housewife to know if it, however ,as that connected load brings in their greatest return and is mostly lighting current. Pressure was brought to bear on the large companies who supplied the central stations, with generating equipment. Thus the popular magazines of that time the ads stressed incandescent lights for the home and fluorescent for the factory with no word as to their relative efficiency.

Check back on what I have outlined and look up the U. S. Government's investigation in this case. I believe it was considered restraint of trade when they tried to stop the incandescent lamp manufacturer from selling to the public. —G. E. H.

NEW BOOKS

Modern Organic Finishes

R. H. WAMPLER. 452 pages, 6 x 8¼ in. Brown clothboard covers. Published by The Chemical Publishing Co., Inc., 26 Court St., Brooklyn 2, N. Y. Price $8.50.

A test that is primarily a book of methods. Descriptions of modern finishing materials and equipment for their application, drying, and conveying are presented. Among the application methods discussed are spraying; dipping; roller coating, and tumble and centrifugal finishing. Drying methods include baking by convection and radiant heat, high-frequency baking and air and force drying. The emphasis throughout is placed on the proper selection and use of materials and equipment to get the best possible finish at minimum cost. Finishing processes for a large variety of manufactured products are discussed together with detailed information on testing and evaluating finishes in general.

Precision Measurement in the Metal Working Industry

Prepared by the Department of Education of the International Business Machines Corp. Volumes I and II, 264 and 290 pages respectively, 8½ x 11 in., blue-gray clothboard covers. Published by the Syracuse University Press, Syracuse, New York. Price Vol. I, $2.75 and Vol. II, $4.75.

These texts, although planned primarily for training workers in the high precision methods used in manufacturing IBM products have been used extensively in the classrooms of government arsenals, Army and Navy schools, industrial classes, and other public and private institutions. Volume I ranges from the use of non-precision line-graduated measuring instruments to dial gages and test indicators, and covers micrometer and vernier test instruments, precision gage blocks, and fixed and thread gages. The more advanced types of precision measuring instruments, machines, and techniques are discussed in Volume II. Among these are surface plates and accessories, angles, comparison measurement, optical instruments, surface roughness and hardness testing.

Lincoln's Incentive System

JAMES F. LINCOLN. 192 pages, 6 x 9 in. brown clothboard covers. Published by the McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York 18, N. Y.

"Incentive management goes far beyond the conception of payment of greater rewards for greater production. Incentive management is a philosophy of industry and life, which starts with the needs of society and depends primarily for its success on the development in the individual of his latent abilities. It is not only a method of wage payment; it is an economic system." Thus, does James F. Lincoln succinctly define the system that has met with such outstanding success in the plants of his Lincoln Electric Company. This plan, in spite of governmental interference, has enabled him to provide high hourly wages, high employment, high production and low selling prices and thereby refute the restriction of output theory that is universal labor union philosophy.

Protective and Decorative Coatings

JOSEPH MATTIELLO. Vol. 5, 662 pages, 6 x 9¼ in. Maroon clothboard covers. Published by John Wiley and Sons, Inc., 440 Fourth Ave., New York 16, N. Y. Price $7.00.

The fifth volume of the Mattiello series on the science of protective and decorative coatings. This latest addition considers the industry's problems from the analytical point of view. It includes a presentation of the approach to the problem of resin analysis and a classification of the resins according to chemical composition. Analytical procedures and normal physical and chemical methods in treating them are discussed. The manner of employing physiochemical properties of the resins in resin analysis is presented in detail; and a discussion of the newer physical methods, such as the spectrochemical techniques of X-ray radiography and diffraction, ultraviolet, visible, infra-red, and Raman spectroscopy is included.

Piezoelectricity

WALTER GUYTON CADY. 806 pages, 6¼ x 9 in., olive clothboard covers. Published by the McGraw-Hill Book Co., Inc., 330 West 42nd St., New York 18, N. Y. Price $9.00.

A comprehensive text on the entire field of piezoelectricity, including the related subjects of elasticity, dielectrics, optics, and magnetism. Beginning with fundamental principles, all aspects of piezoelectric theory and its principle applications are discussed. A unified account is given of experimental results, with many formulas, numerical data, and an extensive bibliography.

Principles of Industrial Process Control

DONALD J. ECKMAN. 237 pages, 5½ x 8½ in. Blue clothboard covers. Published by John Wiley & Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. Price $3.50

In applying automatic control to industrial processes there are certain fundamental principles that apply to the operation of a process when under automatic control, as well as to the functioning of a servomechanism and its positioned element. This book is primarily devoted to the description and explanation of these fundamental principles.

The author carefully observes the four elements in a complete control system; the measuring means, the controller mechanism, the final control element, and the process. Pertinent quantities are defined, and appropriate lag coefficients and time constants are used in a treatment of the dynamic characteristics of control systems.

Experimental lag coefficients are given for many industrial measuring elements. A number of controlled response curves are given and are used to illustrate the effects to be expected when adjusting a controller on the job.

The theory of automatic control is considered with principal emphasis on the controlled and uncontrolled process response curves. The reaction rate-lag method is used to calculate controller settings and reaction rates, and lags are given for a number of representative processes. The cycling period method of setting the reset rate and rate-time controller adjustments is carefully stated and illustrated.

Details of measuring devices and controlling mechanisms are described only when they are necessary to the analysis of principles and characteristics of operation.

More than a hundred references on automatic control are listed throughout the text. A complete glossary of 126 terms and definitions is included as a supplement.

Mathematical Theory of Elasticity

I. S. SOKOLNIKOFF with the collaboration of R. D. SPECHT. 374 pages, 6½ x 9 in., red clothboard covers. Published by the McGraw-Hill Book Co., Inc., 330 West 42nd St., New York 18, N. Y. Price $4.50

A text on the basic theory of mechanics of deformable media. The first three chapters, Analysis of Strain, Analysis of Stress, and Stress-strain Relations provide a thorough foundation in the mathematical theory of elasticity. The latter portion of the book is concerned with the application of the theory to problems on extension, torsion, and flexure of isotropic cylindrical bodies and with variational methods in the theory of elasticity.

Practical Design for Arc Welding

ROBERT E. KINKEAD. Three volumes, 200 pages each. 8¾ x 11¼ in., gray clothboard covers. Published by Hobart Brothers, Troy, Ohio. Price $10 for three-volume set.

A three volume set containing over 300 designs suitable for practical arc welding. Opposite each design plate is a work sheet for developing ideas on how products can be improved through the adoption of arc welding. The fundamental symbols of the American Welding Society are shown with typical applications. Data on what and what not to avoid in the design of arc welded parts is included, together with a section on the natural origin of many complex modern design principles.

PHOTO COURTESY OF THE BETTMAN ARCHIVE

When Furnaces were charged like this...

"STANDARD" was producing 1500 tons of steel per year

Here is an ancestor of the skip-hoist, as it existed in 1873. Bearded workmen with bulging muscles took care of the furnace charging.

Standard Steel's "Emma" furnace had been built six years before, to supply the new Bessemer plant . . . the third to be installed in the United States. Local ores proved too high in phosphorous, however, and the furnace was sold. The plant then switched to the making of crucible steel, producing 1519 tons in 1873.

Today Standard's production capacity from its five open hearth furnaces totals 160,000 net tons. These furnaces permit complete control of the methods used in making and casting the steel—a highly important factor in producing quality forgings and castings.

"Standardize on Standard" is an excellent way to simplify your buying.

BLW THE BALDWIN GROUP **BALDWIN**

FORGINGS AND CASTINGS

The Baldwin Locomotive Works, Standard Steel Works Division, Burnham, Pa., U.S.A. Offices: Philadelphia, New York, Chicago, St. Louis, Washington, Boston, San Francisco, Cleveland, Detroit, Pittsburgh, Houston, Birmingham, Norfolk.

"STANDARDIZE ON STANDARD" FOR YOUR FORGINGS AND CASTINGS

Heat and Corrosion Resistant High Temperature Alloys

This information represents the results of tests conducted by Allegheny Ludlum Laboratories. It also includes data obtained by the University of Michigan, Battelle Memorial Institute and the General Electric and Westinghouse laboratories.

CHROMIUM NICKEL ALLOY S-588

Chromium nickel alloy S-588 is suitable for applications where high strength is required in the range of 1,200 to 1,400 deg. F. The alloy should not be used where conditions are strongly oxidizing, but can be used up to temperatures of 1,500 deg. F. when conditions are reducing or only slightly oxidizing. The alloy is available in billets, bars, wires, sheet, forgings and precision castings.

Analysis Range

Carbon	0.40– 0.50	Molybdenum	3.50– 4.50
Manganese	1.00– 2.00	Tungsten	3.50– 4.50
Silicon	0.30– 0.70	Columbium	3.50– 4.50
Chromium	13.50–18.50	Iron	Balance
Nickel	19.00–21.00		

Physical Properties

Melting point approx., deg. C	1,370
Melting point approx., deg. F	2,500
Density, lb. per cu. in.	0.299
Specific gravity	8.26

Coefficients of Expansion

Temp. Range, deg. C., from 20 to	Coef. per deg. C., $\times 10^{-6}$	Temp. Range, deg. F., from 70 to	Coef. per deg. F., $\times 10^{-6}$
300	13.1	600	7.9
400	14.0	800	8.1
500	14.4	1,000	8.4
600	15.0	1,200	8.6
700	15.5	1,400	8.8
800	15.7	1,500	8.9
900	15.8	1,600	8.9
1,000	16.1	1,800	9.1

Strength at Room Temperature

Tests were made on alloy with 13 to 15 percent chromium

	As rolled	* Heat-treated
Yield strength, 0.02 percent set	67,500	35,000
Ultimate strength, lb. per sq. in.	132,500**	132,000
Elongation in 2 in., percent	16	11
Reduction of area, percent	33	14
Hardness, Brinell	.....	255

* 2,250 deg. F., 1 hr., water quenched; plus 1,500 deg. F. 16 hr., air cooled.

** Strength in rolled condition depends on finishing temp.

Strength at Elevated Temperatures

Test pieces, heat-treated 2,250 deg. F., 1 hr., W.Q., 1,500 deg. F., 16 hr., air

	Test Temperature, deg. F. 1,200	1,300	1,500
Ultimate strength, lb. per sq. in.	88,000	69,000	45,500
Elongation in 2 in., percent	23	20	20
Reduction of area, percent	34	31	32
Hardness, Brinell	201	192	192

Rupture Tests

Time-to-rupture tests are useful in studying variables such as composition and heat-treatment. When carried on for a long time, they provide a measure of structural stability and ductility at heat. They do not supplant creep tests but facilitate the selection of optimum creep loads. In general, creep and rupture strengths increase with the temperature of heat-treatment, while the ductility decreases at the same time. Fig. 1 gives a summary of rupture tests made on alloy S-495 quenched from 2,250-deg. F. Long time tests show that the alloy remains quite ductile under load at heat.

(continued on next page)

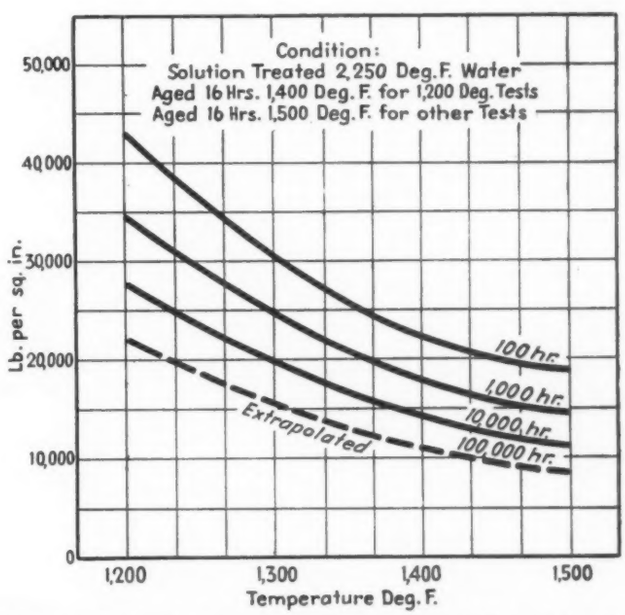
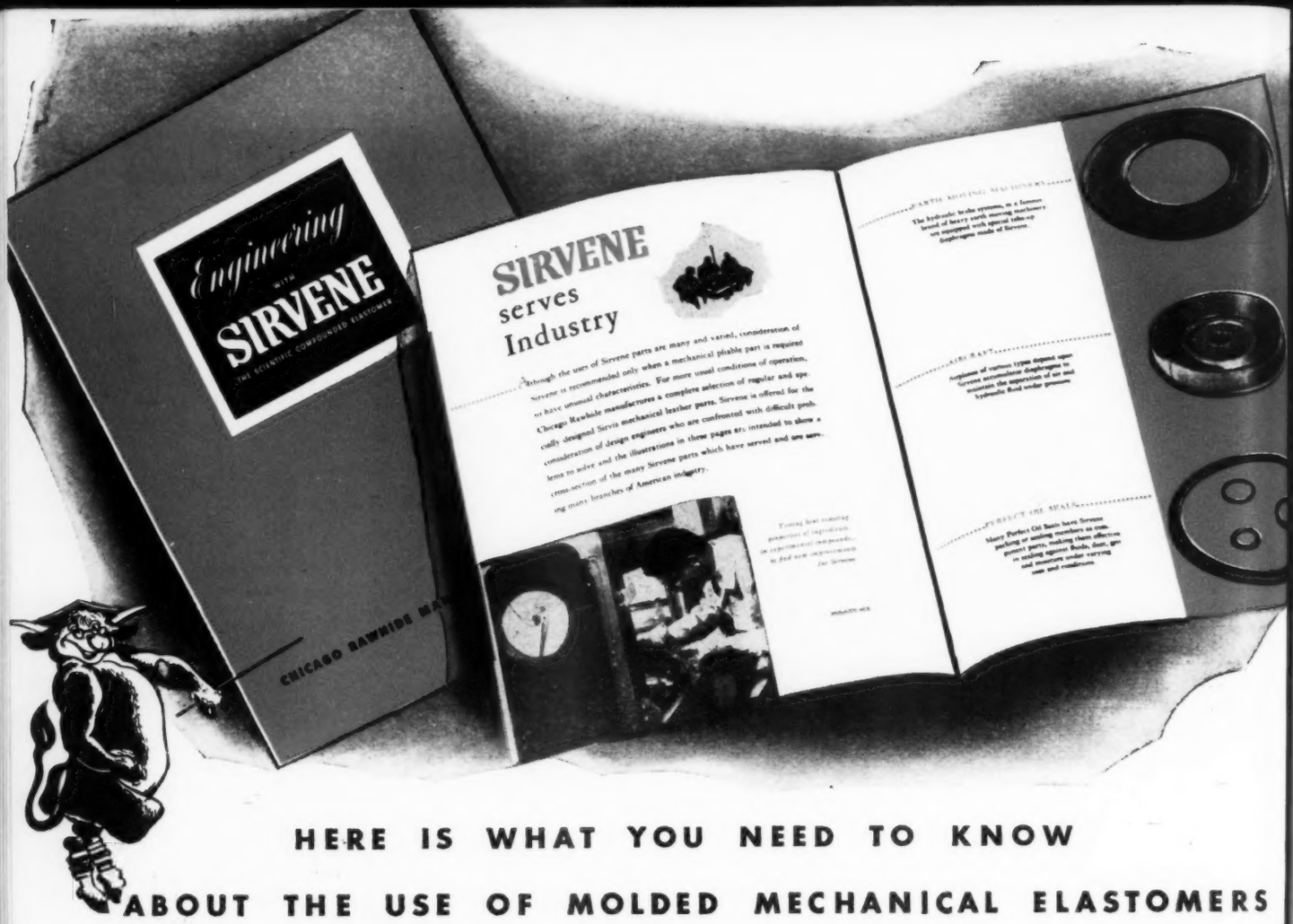


Fig. 1—Rupture times of alloy S-588 at different loads and temperatures.



HERE IS WHAT YOU NEED TO KNOW

ABOUT THE USE OF MOLDED MECHANICAL ELASTOMERS

A complete, factual monograph on the development and application of "synthetic rubber" pliable parts

This new 48-page, graphically illustrated book contains the facts which product engineers need concerning elastomers in general and Sirvene in particular. It provides objective information about the elastomer groups; compounding, manufacture and application of Sirvene; and specific case histories to show how Sirvene has solved seemingly unsurmountable pliable parts problems. It will provide you with the key to **your** parts pro lems which include combinations of flexibili and hardness, resistance to fluids and tempe atures, and dependability under severe pe formance conditions. Without charge, you ma have a copy of "Engineering with Sirvene by writing, on your business letterhead, to:

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Sirvene Engineers are pioneers in the field of scientific compounded elastomers. Since 1929, they have acquired an unequalled background of research, development and manufacturing experience. This unique reservoir of experience is always at your service.

Heat and Corrosion Resistant High Temperature Alloys (continued)

Creep Rates of Rolled Alloy S-588

Test Temp., deg. F.	Stress, lb. per sq. in.	Duration of Test, hr.	Rate of Deformation, percent per hr.		Total Deformation, percent
			1,000 hr.	2,000 hr.	
1,350	20,000	694	0.002	.....	0.766
1,350	15,000	2,016	0.000062	0.000085	0.383
1,500	10,000	2,280	0.000175	0.0004	0.472
1,500	8,000	1,999	0.000012	0.000004	0.115
1,500	5,000	2,019	0.000012	0.000002	0.086
1,600	5,000	2,015	0.000037	0.000064	0.165

Creep Rates of Precision Cast Alloy S-588

Test temp. deg. F.	Stress, lb. per sq. in.	Tested, hr.	Rate of Deformation, percent per hr.		Total Deformation, percent
			1,000 hr.	2,000 hr.	
1,350	15,000	2,016	0.000058	0.00003	0.369
1,350	12,000	2,016	0.00002	0.000015	0.204
1,500	10,000	2,012	0.000028	0.000025	0.165
1,500	8,000	2,014	0.000017	0.00001	0.110

Typical Results Obtained by Aging Treatment

Condition	Brinell	Rockwell
1 hr. 2,250 deg. F., water quenched plus....	187	B 91/92
16 hr. 1,300 deg. F., air cooled	217	C 19/22
16 hr. 1,400 deg. F., air cooled	302	C 31/32
16 hr. 1,500 deg. F., air cooled	293	C 29/31
16 hr. 1,600 deg. F., air cooled	269	C 24/27
16 hr. 1,700 deg. F., air cooled	241	C 21/23
16 hr. 1,800 deg. F., air cooled	229	B 97/100

IMPACT STRENGTH

Condition: As annealed 2,000 deg. F., water quenched

Standard Izod test piece 1 ..... 32 ft.-lb.
Standard Izod test piece 2 ..... 31 ft.-lb.
Standard Izod test piece 3 ..... 30 ft.-lb.

Condition: 2,250 deg. F., 1 hr., water quenched, plus 50 hr., 1,500 deg. F., air cooled. Charpy test piece, V-notch.

Room temperature ..... 7 ft.-lb.
1,500 deg. F. ..... 19 ft.-lb.

FATIGUE STRENGTH

Condition: 2,000 deg. F., 1 hr., water quenched, 16 hr. 1,300 deg. F., air cooled.

Endurance strength* at 1,200 deg. F.... 41,500 lb. per sq. in.

Condition: Cast 2,350 deg. F., 1 hr., water quenched, 20 hr., 1,500 deg. F.

Endurance strength* at 1,200 deg. F.. 26,000 lb. per sq. in.
Endurance strength* at 1,500 deg. F.. 22,000 lb. per sq. in.
*Duration of test 10^8 cycles

MODULUS OF ELASTICITY

At room temperature ..... 29,000,000 lb. per sq. in.
At 1,400 deg. F. ..... 13,000,000 lb. per sq. in.

Heat Treatment

FORGING AND ROLLING. Alloy S-588 is rolled and forged at temperatures of 2,250 to 2,200 deg. F. Drop forging is done about 100 deg. lower. The alloy has a low heat conductivity and low specific heat, therefore, a liberal time of soaking at heat is required. Work hardening takes place even at high heat so that frequent reheatings may be required.

SOLUTION TREATMENT. Alloy S-588 develops optimum properties at heat when heat-treated by a high temperature quench, followed by aging. The properties given here are all based on a solution temperature of 2,250 deg. F. Higher temperatures up to about 2,350 deg. F. result in higher rupture and creep strength at the cost of lower ductility.

Since this alloy scales freely at forging and heat-treatment temperatures, precautions should be taken to reduce scaling to a minimum. Protective atmospheres that are suitable for tool steels may carburize alloy S-588. Hydrogen, nitrogen or mixtures of both such as forming gas or cracked ammonia are considered safe to use.

AGING. Aging can be done in air for a minimum of six hours at 1,400 to 1,500 deg. F.

COLD HOT WORK. Alloy S-588 should not be cold hot worked.

STRUCTURE. The structure of alloy S-588 is an austenitic matrix, through which a second phase that presumably consists of complex carbides is dispersed at random.

MACHINING. Machining is somewhat difficult and should be done at low feeds and speeds using a positive cut. For drilling, the solution treated condition (softest) appears best, but for all other operations the aged hardened condition is usually preferred. The rate of work hardening is high in the solution treated condition, but is low in the aged condition.

CHROMIUM NICKEL COBALT ALLOY S-590

Chromium nickel cobalt alloy S-590 possesses high strength and oxidation resistance at elevated temperatures. It is particularly suitable for use at temperatures in the range of 1,200 to 1,500 deg. F. in applications such as wheels for gas turbines. Alloy S-590 is available in billets, bars, wires, sheet, precision castings and forgings.

Typical Analysis

Carbon	0.43	Cobalt	19.31
Manganese	1.65	Molybdenum	4.33
Silicon	0.66	Tungsten	3.93
Chromium	20.88	Columbium	3.92
Nickel	19.42	Iron	Balance

Physical Properties

Melting point approx., deg. C	1,300
Melting point approx., deg. F	2,400
Density, lb. per cu in.	0.301
Specific gravity	8.34

Coefficients of Expansion

Temp. Range, deg. C., From 20 to	Coef. per deg. C. $\times 10^{-6}$	Temp. Range, deg. F., From 70 to	Coef. per deg. F. $\times 10^{-6}$
300	14.1	600	7.6
400	14.2	800	7.7
500	14.6	1,000	8.0
600	14.7	1,200	8.0
700	14.9	1,400	8.3
800	15.3	1,500	8.4
900	15.4	1,600	8.4
1,000	15.2	1,800	8.4

(continued on next page)

Hints for Product Designers and Engineers

PEACETIME planning and product development suggest a busy year ahead. Be foresighted . . . make your first research job one of taking inventory of your work-kit of drafting and designing "sundries" . . . never so needed as when you've failed to provide for them.

Here are a few suggestions to help you select materials that are guaranteed to give satisfaction.

WEATHERPROOF VAN DYKE Thin Colored Pencils—with insoluble leads that set a new standard in pigment-to-paper writability. Eberhard Faber genius has created legible color, plus strong, keen points and long wear. This should be your first choice for charts, color-coded drawings, or wherever else you need moisture-proof color markings.

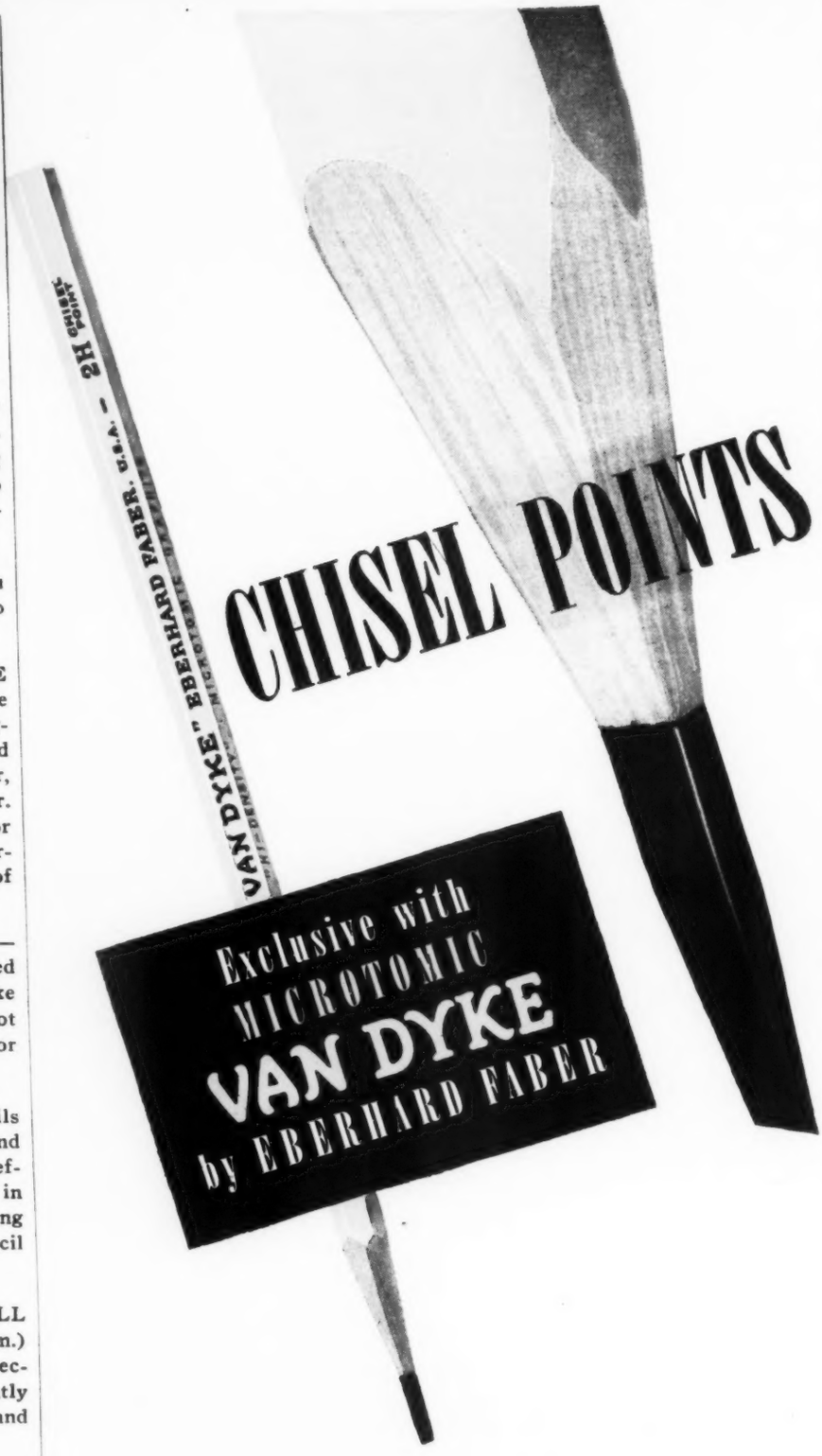
VAN DYKE Blueprint Pencils — Strong, thin leads in white, blue, red and yellow for fine detail work. Make intensely sharp, even lines. Will not smear or smudge. Unexcelled for working directly on blueprints.

MONGOL Thin Lead Colored Pencils —For charts, graphs, checking and color coding. Used also for wash effects (with brush and water). Made in 24 brilliant colors, exceedingly strong thin leads than can be pointed in pencil sharpener.

MONGOL and VAN DYKE REFILL Leads—in extra thin (.036" diam.) and standard (.046" diam.) Wide selection of degrees and colors conveniently packaged. For automatic pencils and draftsmen's instruments.

ERASERS—for all purposes—surface cleaning, removing lightly penciled lines or even ink when necessary. Look for the name . . . EBERHARD FABER.

Better plan now to continue your Research on Better Pencils for Better Work, with a visit to the Eberhard Faber Accredited dealer in your city. He can assist you in your further selection of needed professional items.



IDEAL for large dimension tracing sheets calling for extra long lines of unvarying width. Rectangular-shaped, HI-DENSITY Lead sharpens to a super-efficient chisel point that delivers greater line production between repointings. Test this exclusive EBERHARD FABER time-saver at any accredited "Van Dyke" Dealer.

Chisel Point Leads come in degrees: 6H, 4H, 2H, HB, 2B, 4B. Round Leads in 18 degrees from 9H to 7B.

Strength at Room Temperature

Tests made on standard 0.505 in. dia. test specimens

	* As Rolled	** Heat-Treated	Precision Cast
Yield strength, 0.02 percent offset	80,000	42,000	37,000
Yield strength, 0.2 percent offset	109,000	69,000	66,000
Ultimate strength, lb. per sq. in.	152,000	140,000	84,000
Elongation in 2 in., percent	19	20	4
Reduction of area, percent	25	19	10

* Strength in the rolled condition depends on the finishing temperature.

** 2,250 to 2,300 deg. F. for 1 hr., water quenched; plus 1,400 deg. F. for 16 hr., air cooled. Results are average of many tests.

Strength at Elevated Temperatures

Test pieces heat-treated 2,300 deg. F., 1 hr., water quenched, plus 1,500 deg. F., 16 hr., air cooled.

Test pieces held at test temperature for 40 minutes, then pulled at a rate of 0.05 in. per minute.

	Test Temperature, deg. F. 1,200	1,350
Yield strength, 0.02 percent offset	49,000	46,000
Ultimate strength, lb. per sq. in.	81,600	65,750
Elongation in 2 in., percent	27	25
Reduction of area, percent	31	30

Rupture Tests

A summary of the results of rupture tests made on alloy S-590 quenched from 2,250 deg. F. is given in Fig. 2. Long time tests show that the alloy remains quite ductile under load at heat.

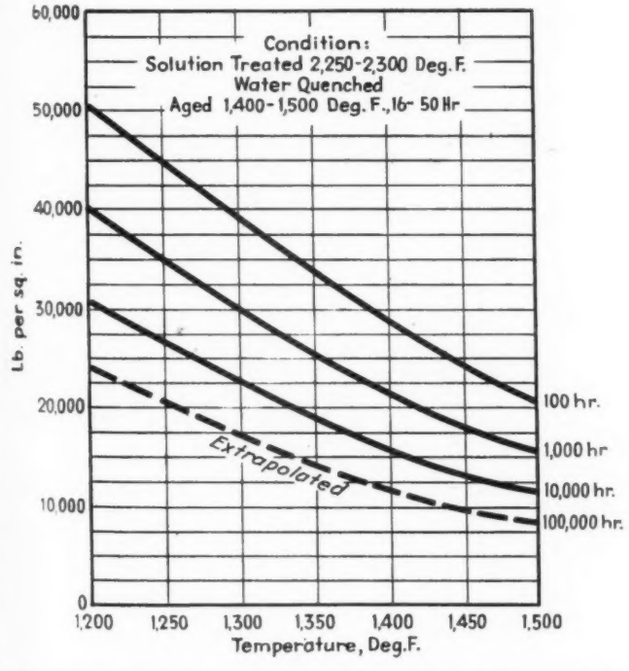


Fig. 2—Ruptured times of Alloy S-590 at different loads and temperatures

Creep Rates of Heat-Treated* Alloy S-590

Test Temp., deg. F.	Stress, lb. per sq. in.	Duration of Test, hr.	Rate of Deformation, percent per hr. 1,000 hr.	2,000 hr.	Total Deformation, percent
1,200	35,000	1,005	0.00087	.....	1.368
1,200	25,000	1,010	0.00025	.....	0.436
1,500	10,000	2,043	0.00011	0.00014	0.565
1,500	8,000	2,018	0.000047	0.000045	0.240
1,500	10,000	2,035	0.000067	0.000062	0.371
1,500	8,000	2,012	0.000035	0.000021	0.224

* Heat-treatment: 2,300 deg. F., water quench, 1,400 deg. F. for 16 hr., air cooled.

Typical Results Obtained by Precipitation Hardening

Condition	Brinell	Rockwell C
2,300 deg. F., water quenched plus 16 hr. 1,300 deg. F., air cooled	241	20/22
16 hr. 1,400 deg. F., air cooled	255	24/26
16 hr. 1,500 deg. F., air cooled	269	25/27
16 hr. 1,600 deg. F., air cooled	302	30/32
16 hr. 1,700 deg. F., air cooled	293	29/31
16 hr. 1,800 deg. F., air cooled	269	24/27
	269	24/26

Impact Strength

Condition: Heat-treated at 2,300 deg. F. for 1 hr., water quenched plus 1,500 deg. F. for 16 hr. Charpy test piece, V-notch.

Room temperature	8 ft.-lb.
1,500 deg. F	27 ft.-lb.

Modulus of Elasticity

At room temperature	29,000,000 lb. per sq. in.
At 1,400 deg. F	16,000,000 lb. per sq. in.

Heat-Treatment

Forging and Rolling	Same as Alloy S-588
Solution Treatment	Same as Alloy S-588
Aging.	Aging can be done in air for a minimum of ten hours at 1,400-1,500 deg. F.
Cold Hot-Work	Alloy S-590 should not be cold hot-worked
Structure	Same as Alloy S-588
Machining	Same as Alloy S-588

CHROMIUM NICKEL COBALT ALLOY S-816

Chromium nickel cobalt alloy S-816 possesses very high strength and oxidation resistance at elevated temperatures. It is best adapted for service in the range of 1,200 to 1,500 deg. F. in applications such as buckets for gas turbines in which both high temperatures and high stresses much be resisted. The alloy is available in billets, bars, wire, sheet, precision castings and forgings.

Typical Analysis

Carbon	0.38	Cobalt	42.28
Silicon	0.39	Molybdenum	4.30
Manganese	0.49	Tungsten	4.26
Chromium	19.84	Columbium	3.77
Nickel	20.17	Iron	4.09

(continued on next page)

3 TYPES OF *Flexible* Connections ...each offers distinct advantages

1 Withstands Frequent Flexing

"American" *Helical* Seamless Flexible Tubing. Particularly well adapted to services involving frequent or constant flexing. Available unbraided or with single, double or triple "basket weave" wire braid, with or without reinforcing armor, and with or without fittings attached.

2 Aids Maintenance Men

"American" *Annular* Seamless Flexible Tubing. Each convolution is a complete and separate circle or ring in itself. Heat proof Reattachable Couplings (illustrated) can be readily attached and detached with standard shop tools. Ideal where assemblies must be made up "on the job."

3 For Moderate Pressures

"American" Strip-Wound Metal Hose is available in four popular types, some without packing, others packed with asbestos, cord, rubber or wire. Made in brass, bronze, galvanized or stainless steel and other workable metals. Used for carrying steam, water, oil, hot air, grinder dust, chips or light, dry material.

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American Metal Hose Branch

General Offices: Waterbury 88, Connecticut

Subsidiary of Anaconda Copper Mining Company

In Canada: ANACONDA AMERICAN BRASS LTD., *New Toronto, Ont.*

IN THOUSANDS of plants throughout the country, flexible connections of the types shown are safely and economically conveying oil, water, steam, gases and semi-solids. Engineered to absorb vibration, compensate for misalignment, or allow for movement of parts, such connections withstand heat, pressure, abrasion and corrosion. Detailed information? Write for Bulletin SS-50.

Heat and Corrosion Resistant High Temperature Alloys (continued)

Physical Properties

Melting point approx., deg. C	1,300
Melting point approx., deg. F	2,400
Density, lb. per cu. in.	0.313
Specific Gravity	8.66

Coefficients of Expansion

Temp. Range deg. C., From 20 to	Coef. per deg. C. $\times 10^{-6}$	Temp. Range deg. F., From 70 to	Coef. per deg. F., $\times 10^{-6}$
300	11.8	600	6.6
400	12.4	800	6.9
500	12.7	1,000	7.1
600	13.0	1,200	7.4
700	13.5	1,400	7.7
800	14.0	1,500	7.8
900	14.4	1,600	8.0
1,000	15.0	1,800	8.3

Strength at Room Temperature

Tested as standard 0.505 in. dia. test specimens

	As Rolled	* Heat-Treated	Precision Cast
Yield strength, 0.02 percent offset	73,000	68,000	59,000
Ultimate strength, lb. per sq. in.	175,000**	159,000	112,000
Elongation in 2 in., percent	39	21	5
Reduction of area, percent	45	20	13

* 2,250 deg. F., 1 hr., water quenched; plus 1,400 deg. F., air cooled.

** Strength in rolled condition depends on finishing temp.

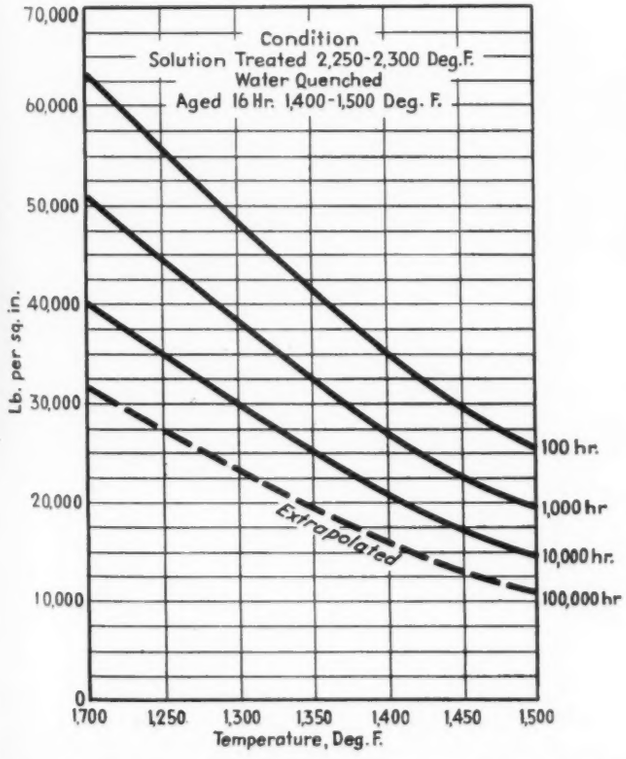

Fig. 3—Rupture times of Alloy S-816 at different loads and temperatures

Strength at Elevated Temperatures

Test pieces heat-treated 2,300 deg. F., 1 hr., water quenched, 1,400 deg. F., 16 hr., air cooled.

Test Temp. deg. F.	Ultimate Strength, lb. per sq. in.	Elongation in 2 in., percent	Reduction of Area, percent
1,000	132,350	22	20
1,200	120,200	17	22
1,350	98,900	15	22
1,500	78,262	12	21
1,600	59,767	18	20
1,700	46,177	14	17

Rupture Tests

A summary of the results of rupture tests made on alloy S-816 quenched from 2,250 deg. F. is given in Fig. 3. Long time tests show that this alloy retains a fair degree of ductility under load at heat.

Creep Rates of Heat-Treated Alloy S-816

Test Temp., deg. F.	Stress, lb. per sq. in.	Duration of Test, hr.	Rate of Deformation, percent per hr.		Total Deformation percent
			1,000 hr.	2,000 hr.	
1,500	10,000	2,011	0.000149	0.00014	0.371
1,500	8,000	2,017	0.00008	0.000055	0.224

Typical Results Obtained by Precipitation Hardening

Condition	Brinell	Rockwell C
2,350 deg. F., water quenched plus 16 hr. 1,400 deg. F., air cooled	255	25/27
16 hr. 1,400 deg. F., air cooled	311	31/32
16 hr. 1,500 deg. F., air cooled	311	32/33
16 hr. 1,600 deg. F., air cooled	311	32
16 hr. 1,700 deg. F., air cooled	293	29/31
16 hr. 1,800 deg. F., air cooled	285	29/30
16 hr. 1,900 deg. F., air cooled	277	26/28

Impact Strength

Condition: Heat-treated 2,300 deg. F., 1 hr., water quenched, plus 1,500 deg. F., air cooled.
Charpy test specimens, V-notch.

At room temperature	26 ft.-lb.
At 1,500 deg. F.	45 ft.-lb.

Fatigue Strength

Condition: Heat-treated 2,300 deg. F., 1 hr., water quenched, plus 1,500 deg. F., air cooled.

Endurance strength at 1,200 deg. F.	68,000 lb. per sq. in.
Endurance strength at 1,500 deg. F.	33,000 lb. per sq. in.
Duration of test 10^8 cycles.	

Modulus of Elasticity

At room temperature	31,000,000 lb. per sq. in.
At 1,400 deg. F	15,000,000 lb. per sq. in.

Heat-Treatment

Forging and Rolling	Same as Alloy S-588
Solution Treatment	Same as Alloy S-588
Aging	Same as Alloy S-588
Cold Hot Work	Alloy S-816 should not be cold hot-worked
Structure	Same as Alloy S-588
Machining	Same as Alloy S-588
Welding	Alloy S-816 can be welded by the atomic hydrogen, electric arc or electric resistance methods.

When mill-ordered Armco steels are unloaded in your plant you can be sure of this:

The steel is "job-tailored" to your needs—*before* and *during* rolling operations. Salesmen, metallurgists, and mill representatives all see that you get the *one right steel* for your products.

For almost 20 years Armco men have called this "Q. C."—Quality Control. Metallurgists who study your requirements specify the analysis of steel, the temper rolling, annealing, and all other operations that affect the qualities of the finished sheets. Then mill operators follow through with these instructions on your individual routing card.

In recent years, Armco control charts and statistical analyses have further helped to assure consistent production of prime steels. They are an added safeguard for the sheets that go into your products.

"Quality Controls" like these are one reason why leading manufacturers look first to Armco for special-purpose sheet steels.

Back of it all are the research and experience that contribute to a higher "Q. C." at our end and better quality at yours. The American Rolling Mill Co., 3701 Curtis St., Middletown, O.

ARMCO

The American Rolling Mill Company

Special-Purpose Sheet Steels • Stainless Steel Sheets, Bars and Wire

NEW MATERIALS AND PARTS

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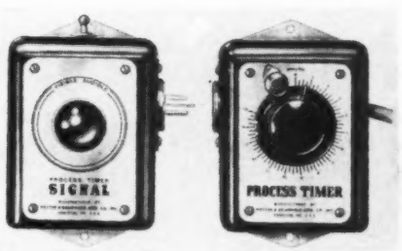
Process Timer

Potter & Brumfield Sales Co., Dep't. 231, 549 West Washington Blvd., Chicago 6, Ill.

The Type TA unit is powered with a synchronous motor that actuates a pair of silver contacts rated at 1,000 watts or 1 h.p. load. A single 3-way outlet mounted on the side of the case permits connection to the load for "on during cycle" or "off during cycle" and "come on at end of cycle." The contacts are snap-acting. The case is of molded plastic with holes in the back plate for screw mounting. The timer operates in any position. The knob is 1¼ in. diameter and ⅞ in. high. Any desired time interval to the limit of the unit can be preset and the same time cycle will be repeated at each manual resetting, or the



stop can be released and the desired interval set each time by the graduations on the dial. Standard time cycles are from 0-15 min.; 0-30 min.; 0-1 hr. and 0-12 hr. Other time cycles are available on order. Size of unit, 5½ x 3¼ x 3½ in. A companion piece to the Type TA process timer is the "Type A" signal indicator. Housed in a molded plastic case similar to the TA timer, the signal indicator contains a buzzer and light. It can be mounted in any position, and is fitted with a male three-way plug that can be connected directly into the socket on the TA timer, or located at any distance by use of a 3 wire cord. The buzzer and light can be disconnected from the circuit if desired. Reset of the timer knob instantly turns signal off.

Split Bolt Connectors

Ideal Industries, Inc., 1446 Park Ave., Sycamore, Ill.

Available in two types, "one-piece" and "two-piece" with small and large heads, these connectors are made either in bronze, brass, or aluminum. There are no burrs, ends, or sharp edges. Uniform contact surfaces assure maximum conductivity and low resistance. A range of sizes accommodates all solid and stranded wire from No. 6 to 1,000,000 cir.m. Service entrance connectors are made from cold-drawn copper with the screws made from Everdur.

Low-Inertia Motor

Transicoil Corp., 114 Worth Street, New York, N. Y.

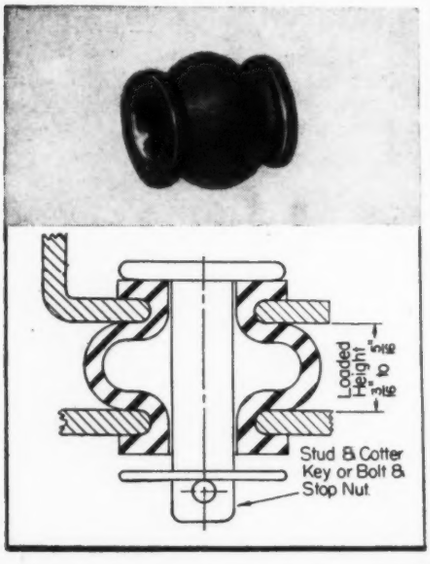
A compact, low inertia, 60 cycle, 2 phase unit for remote control applications. Designated as Model 2A Servo-Motor, this unit does not run single phase and the fixed phase can be continously energized. It can be wound to operate from 10 to 80 volts, or more; 60 cycles. Impedance is constant from full speed to stall, and the standard stall torque, 1½ oz. in. can be changed as required. Stack length can be changed plus or minus 50 percent to suit torque re-

quirements. This will change the overall length a maximum of $\frac{3}{8}$ in. The Servo-Motor is furnished with separate leads for each phase; terminal board can be attched to rear of motor, if required.

Vibration and Shock Isolator

L. N. Barry Co., Inc., 179 Sidney St., Cambridge 39, Mass.

A unit for isolating vibration frequencies as low as 15 c.p.s. in all directions with resonances as low as 9 c.p.s. Full isolation is given for loads from 5 oz. to 3 lb. per



mount. This isolator provides for use of stud with washer and cotter key, or bolt and stop nut as a safety retainer and excursion limiter with rubber snubbing. For mounting, it requires one hole in the unit and one in the base for each mount.

Selenium Rectifier

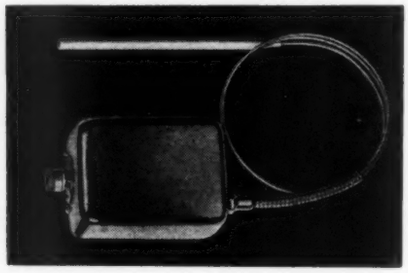
Federal Telephone and Radio Corp., Newark, N. J.

Known as type 403D-2625, this rectifier consists of five square selenium plates made on aluminum base plates, connected in series, with center contact and measures 1 1/4 x 1 1/4 x 11/16 in. The unit has a rated current carrying capacity of 100 milliamp. d.c. and a peak inverse voltage of 330 volts. Receiver circuits using this rectifier become operative instantaneously, no warm-up period is necessary.

Thermostat

United Electric Controls Co., Boston 27, Mass.

A type O thermostat of the remote-bulb type, designed for industrial applications requiring control of temperatures over narrowly calibrated ranges. This unit can be

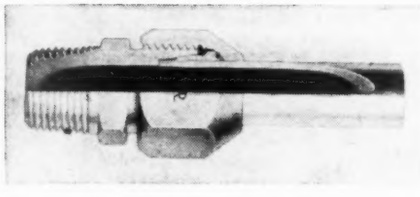


used for all liquids or gases non-injurious to brass, or for metal to metal applications and can be equipped with ambient temperature compensation. Control is based on a snap-action switch actuated by a liquid-filled copper thermal assembly. This assembly has an unvarying and rapid expansion and contraction per degree of temperature change and can be adjusted. Adjustments are graduated in increments of 120 or 250 deg. F. in the range from —120 to 600 deg. F. Four bulb types are available for use with this unit.

Flareless Fitting

The Parker Appliance Company, Cleveland, Ohio

A fitting for joining all types of metal tubing, in hydraulic and fluid-conveying systems. The unit has a steel ferrule, which when body and inclosing nut are



tightened up, cuts a shoulder in the tubing itself. Joints on which the fittings are used can be broken without affecting reseal-ability. Available in $\frac{1}{4}$ to 1 in. O. D. tube sizes, in all conventional shapes and materials, the fittings are threaded identically in size and pitch with the corresponding flared fitting.

Sealnut

Radio Frequency Laboratories, Inc., Boonton, N. J.

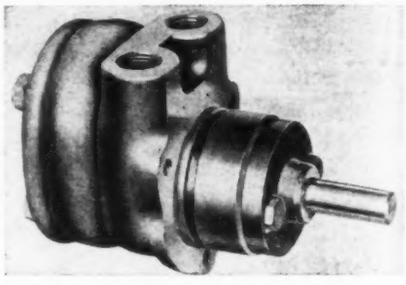
A mounting-and-sealing nut that is claimed to prevent dirt, water or gas from entering equipment panels around switch and control shafts. An elastic sleeve grips the protruding shaft or switch handle. Base of nut is sealed to the panel by an internal

rubber ring that permits metal-to-metal contact between nut and panel. Applications include pressurized and moisture-proof equipment. Can be substituted for the standard mounting nut on components of equipment now in service without alterations.

Rotary Pumps

Geo. D. Roper Corp., Rockford, Ill

The Series K pumps in sizes of 3/4, 1 1/2, and 3 gals. per min., are designed to cover a range of applications. Working pressures vary to 150 lb. per sq. in. at a designed



operating speed of 1740 r.p.m. The pumps can be hub, flange, or foot mounted and are equipped with 3/8 in. pipe connections. They are claimed to be particularly well suited for diesel lube oil transfer work, for pressure lubrication work, and for actuating hydraulic mechanisms.

Self-Emulsifying Solvent

Oakite Products, Inc., 57 Thames St., New York 6, N. Y.

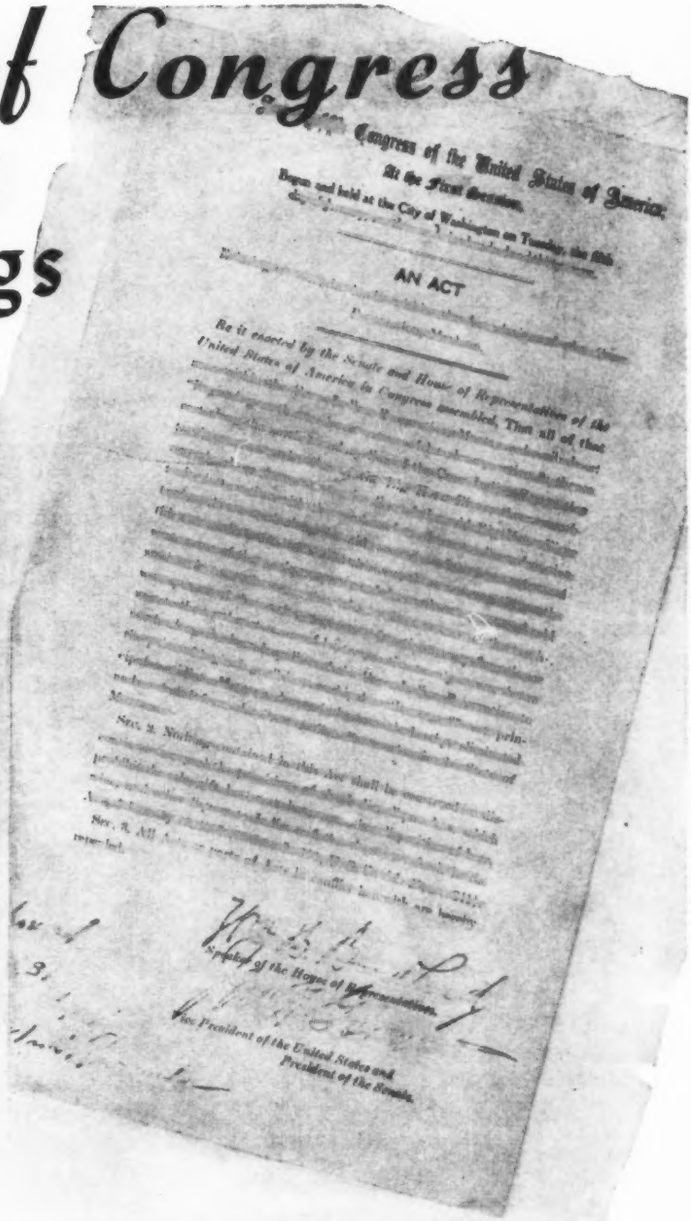
A self-emulsifying, water-mixable solvent, called Oakite Composition No. 98, that removes light shop dirt and non-pigmented stamping compounds from steel and aluminum work. Non-toxic and non-flammable in solution, this material is claimed to have self-cleaning properties. The lighter-than-solution soil floats at the top of the cleaning tank to blanket and protect the clean solution underneath; retard foaming; and prevent material loss by evaporation. The solvent prevents formation on clean work of water spots, which often show through clear lacquer and other types of organic finishes. Working concentrations range from one to two per cent by volume, and maximum temperatures should not exceed 150 deg. F.

Electronic Servomechanism

W. C. Robinette Co., 802 Fair Oaks Ave., South Pasadena, Calif.

The Motron Servo Model 61 A is a packaged continuous-balance control system that can be applied to the automatic control or regulation of processes. Miniature vacuum tubes control the speed and direction of a standard 1/15 h.p. induction

An Act of Congress concerning Sleeve Bearings


Congress of the United States of America;
AT THE FIRST SESSION,
Begun and held at the City of Washington on Tuesday, the fifth
AN ACT
Be it enacted by the Senate and House of Representatives of the
United States of America in Congress assembled, That all of that
Speaker of the House of Representatives.
Vice President of the United States and
President of the Senate.

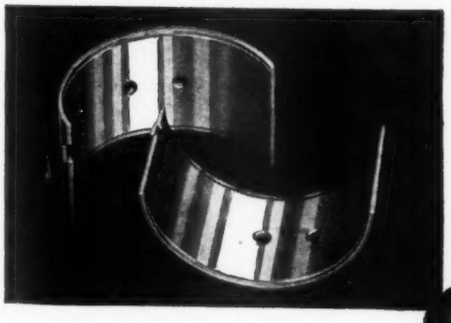
ONCE in a while a great invention is not patentable. Such was the case when Isaac Babbitt in 1839 discovered the remarkable bearing metal which he called "Babbitt." He combined tin, copper and antimony to produce this alloy. Because his idea was recognized as extremely important, and could not be patented, he was rewarded with a gold medal from the Massachusetts Charitable Mechanics Association and an award of $20,000 from the Congress of the United States.

This honor and award were small recompense, indeed, for the millions of dollars his invention has saved industry. No other bearing metal possesses such a low coefficient of friction. When laminated to either bronze or steel it forms the most efficient and satisfactory bearing for certain applications—particularly for all types of internal combustion engines. Today you will find millions of babbitt-lined bearings in use. In giant diesel engines . . . in all types of aircraft . . . in your car or truck . . . they deliver smooth, quiet performance for thousands of miles or hundreds of hours of steady operation.

Manufacturers find Johnson Bronze a capable, experienced, and dependable source of supply for all types of sleeve bearings, including babbitt-lined. Our advice and counsel are available without obligation.

JOHNSON BRONZE COMPANY

508 SOUTH MILL STREET NEW CASTLE, PA.



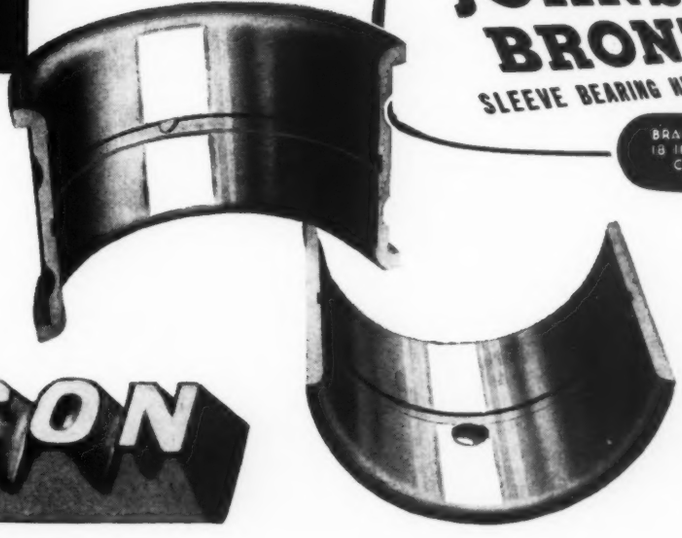
Automotive Slip-In Bearings with babbitt permanently bonded to strip steel.

Bars of Babbitt are used by machine shops in making repairs on the job

JOHNSON BRONZE

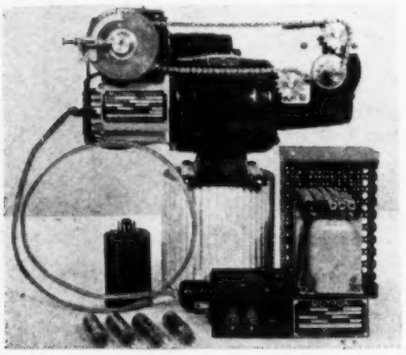
SLEEVE BEARING HEADQUARTERS

BRANCHES IN 18 INDUSTRIAL CENTERS



Huge Diesel Bearings are bronze-back, babbitt-lined

JOHNSON

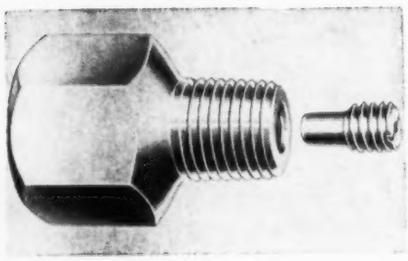


motor, according to the setting of the input-dial. This dial is mounted on ball bearings and controls either the velocity or position of the motor. The velocity in either direction can be limited from zero to maximum, independent of input-dial setting. The motor can actuate any device or mechanism (with 30-75 in. lb. torque, 0-29 r.p.m.) that controls the process, state, or condition that is measured on the input-dial, thus controlling and regulating the process. Alternately the motor may act as a torque amplifier or remote positioning agent. The 61 A servo is designed for short time-constant systems.

Cartridge Snubber

Helicoid Gage. Div., American Chain & Cable Co., Inc., Bridgeport 2, Conn.

A snubber, or pulsation dampener, using powdered metal through which the pressure medium is passed. The compressed powdered metal, in a cartridge, is inserted in the gage socket, or in a small separate



connecting piece attached to the gage socket. The compressed powdered metal is made in various porosities for air, gas, water, steam, or oil. It is claimed that this unit is effective in reducing or eliminating violent pressure pulsations.

Dewpoint Recorder

General Electric Co., Schenectady, N. Y.

Designed for applications where the moisture content of atmospheres and gases must be measured or controlled, this unit is a combination of heater, refrigerator, mirror and gas chamber. The test gas enters the gas chamber and comes in contact with a metal mirror. The refrigerator and heater cool or heat the mirror until a temperature is attained at which moisture in the gas forms dew on the mirror. A photoelectric eye watches the mirror, and the mirror temperature is recorded on a graph or chart the moment dew forms. Working in co-ordination, the refrigerator and heater hold this dewpoint temperature within a tolerance of 2 deg. so that a continuous reading on the chart is achieved. The dewpoint temperature that is recorded can then be converted into the moisture content of the gas. The recorder can be arranged to flash or sound a warning when moisture in the gas reaches too high or too low a level, or control other equipment that will dehumidify or add moisture to the gas. The instrument is designed for operation at atmospheric pressure over a dewpoint range from ambient to —90 deg. F.

Television Rectifier

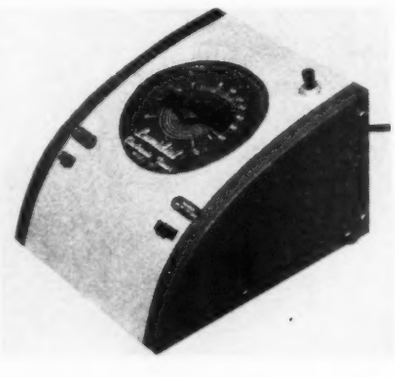
Chatham Electronics, 475 Washington St., Newark 2, N. J.

The Chatham type 1Z2 small bulb, high voltage vacuum rectifier is designed for low current capacity. The low cathode heating power and low dielectric losses make this tube suitable for use in rectifiers operating from a radio frequency supply. Two tubes in a voltage doubler will supply 20,000 volts at 2 ma. d.c. Maximum ratings: Peak inverse voltage 20,000 volts, average plate current 2 ma., peak plate current 10 ma.

Electronic Timer

Assembly Products, Inc., Chagrin Falls, Ohio

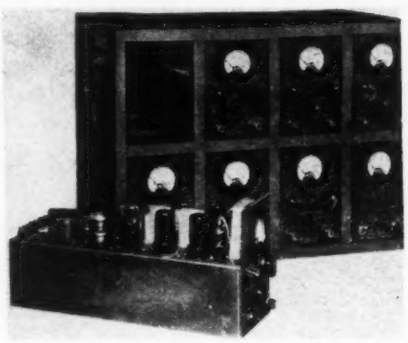
Designed for applications requiring accurate time intervals from 0 to 60 sec. The dial calibrations are spread from 0 to 1 sec. The timer has a luminous dial and a regulator adjustment for timing under all variations of line voltage or other local conditions. Operation is automatic. When time interval is set, starting button begins operation and cycle is completed without further attention. Cycle can be repeated continuously without resetting. A touch of the dial indicator will stop, change or extend the time interval at any point in the cycle. Push button switch permits manual control when desired. The timer is of all metal construction. A single Thyratron tube is used and the timer operates all light wattages to 500 on standard 110 v. circuits. Available in a.c. and a.c.-d.c. models.



Strain-Gage Amplifier

General Electric Co., Schenectady 5, N. Y.

Designed for use with resistance-wire, electromagnetic and magnetostrictive strain gages, this unit amplifies small electric signals varying in frequencies from 0 to 1,000 cycles per sec. It is operated in conjunction

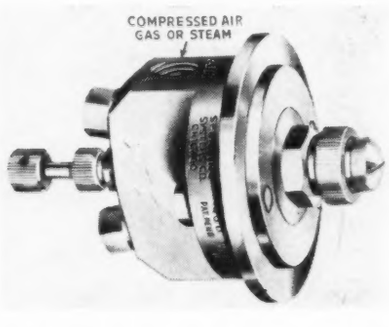


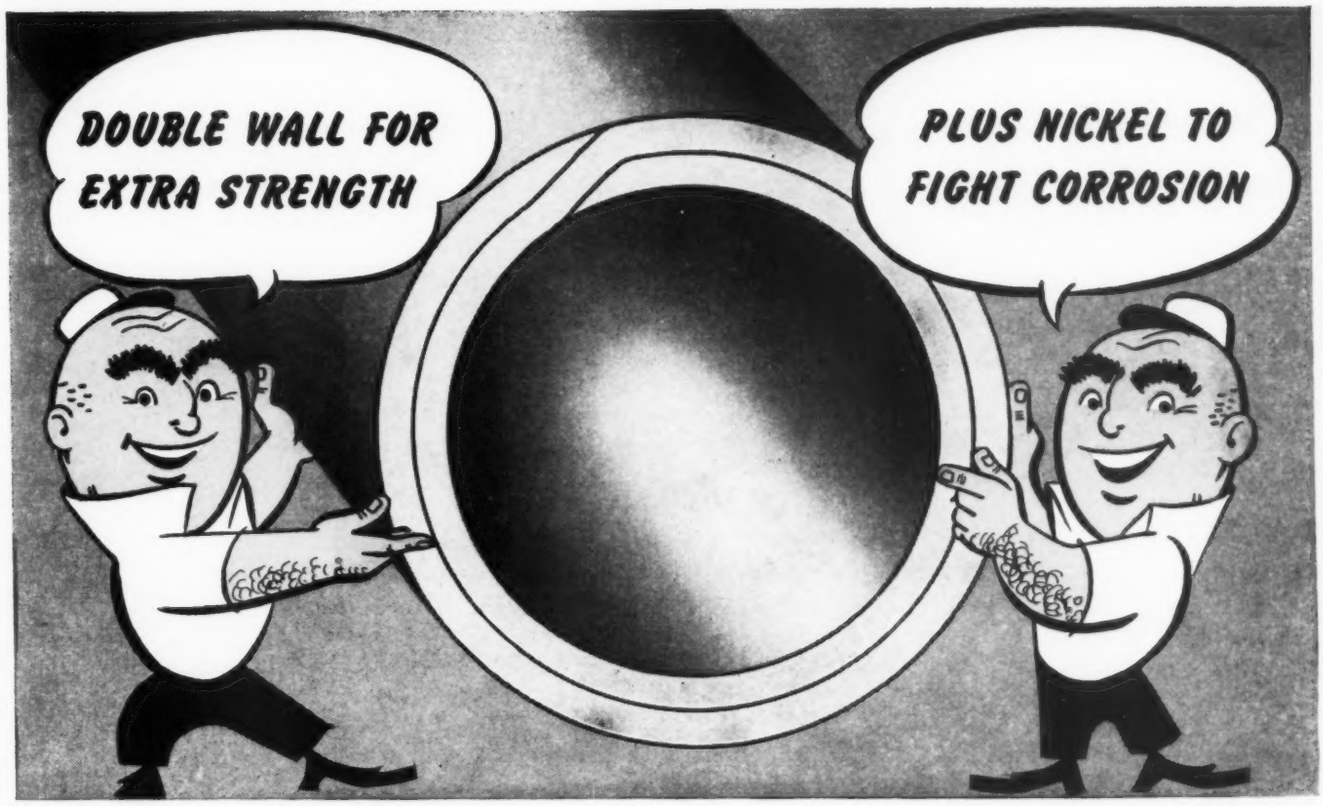
with either a magnetic oscillograph or a cathode ray oscilloscope, and is available for use on 115-volts, 60-cycle a.c. or for battery operation at 24 volts. The amplifier consists of a 5,000-cycle oscillator unit, a power unit, and either two or six identical amplifier units, all mounted in separate chassis. The amplifier channels are stabilized against line voltage change or variations in tube characteristics, and each can be removed for servicing and inspection.

Atomizing Nozzle

Spraying Systems Co., 4085 West Lake St., Chicago 24, Ill.

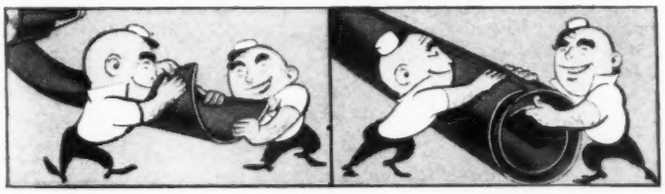
A pneumatic unit having a removable mounting flange that is part of the nozzle assembly and a Monel metal screen or strainer in both the air and water intake chambers of the nozzle body. The nozzle body is held to the flange by two bolt heads. To prevent clogging of the nozzle orifice, core assemblies with fine mesh Monel metal screen are installed in both the air and liquid intake chambers of the





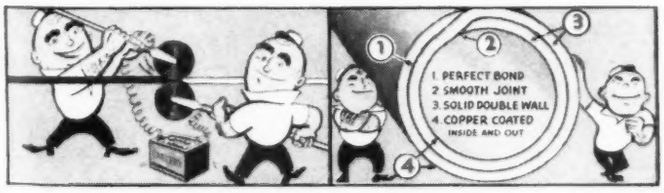
Bundyweld Nickel Tubing Now Available in Quantity

WHY BUNDYWELD IS BETTER TUBING



1 The Bundyweld process is entirely different from that used in making any other tubing. A single strip of metal—copper coated—is continuously rolled twice laterally into tubular . . .

2 form. Uniform wall thickness and concentricity are assured by using close tolerance cold-rolled strip. This double-rolled strip passes through a resistance heating unit where the copper coating . . .



3 fuses and alloys with the Monel or nickel, forming a perfect bond between the two walls and disappearing from the inner and outer surfaces. After cooling, it is a solid, double walled tube . . .

4 copper-brazed throughout 360° of wall contact, free from scale and closely held to dimensions. Hard or annealed in standard sizes to 5/8" O.D. Special sizes cold drawn.

Now available in quantity, Bundyweld Tubing in nickel, Monel and nickel alloys gives you all the advantages of the unique Bundyweld construction:

- PERFECT BOND
- SMOOTH JOINT
- SOLID DOUBLE WALL

PLUS NICKEL'S RESISTANCE TO CORROSION!

Every eight hours, half a million feet of Bundyweld Tubing rolls out of our plant to find its way into hundreds of successful industrial applications . . . from motor vehicles to cooling equipment, from gas ranges to diesel engines.

If the tubing you use must have outstanding mechanical properties, plus resistance to corrosion, the odds are that Bundyweld Tubing in nickel, Monel and nickel alloys will meet your requirements. Write today. *Bundy Tubing Company, Detroit 14, Michigan.*

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★ ★ ENGINEERED TO YOUR EXPECTATIONS ★ ★

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METAL GOODS CORP.
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HOUSTON 1, 16 DRENNAN
NEW ORLEANS 13, 432-438 JULIA ST.
TULSA 3, 19 EAST CAMERON ST.

PACIFIC METALS CO., LTD.
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SAN FRANCISCO 10, 3100 19TH ST.

STEEL SALES CORP.
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DETROIT 10, 5151 WESSON AVE.
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COLUMBUS 15, 31 NORTH GRANT AVE.
PITTSBURGH 12, 901-937 PENNSYLVANIA AVE., N.S.
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BOSTON 41, 235 BRIDGE ST., CAMBRIDGE, MASS.
BUFFALO 2, 284 COURT ST.
NEWARK 5, 205 FRELINGHUYSEN AVE.
NEW YORK 14, 303 WEST 10TH ST.
PHILADELPHIA 40, 1955-75 HUNTING PARK AVE.
SYRACUSE 2, 242 W. WASHINGTON ST.

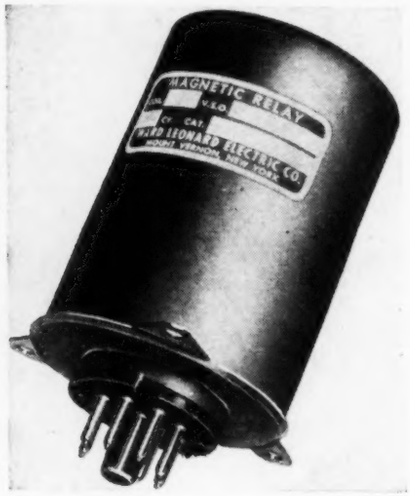
LOCK WASHERS

nozzle body. Screens are removable for cleaning. Nozzles of this type atomize liquid pneumatically by air, gas, or steam pressure. Water, oil, and liquids with similar viscosities can be sprayed.

Plug-In Relays

Ward Leonard Electric Co., Mount Vernon, N. Y.

Coil and contact connections of this unit are inclosed within a metal housing and brought to the prongs of a standard octal plug base. The relays are available in con-



tact combinations to double pole, double throw with a.c. contact ratings (at commercial frequencies) of 4 amp. from 0 to 115 volts and d.c. contact ratings at 5 amp. from 25 to 115 volts.

Dial Indicators

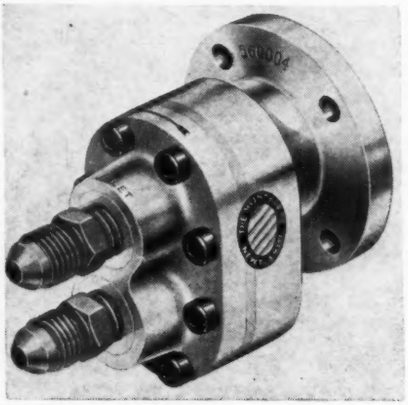
Federal Products Corp., Providence, R. I.

The overall bezel diameter of these units is 1¼ in. They are designed for use where there is not space enough for a large indicator, or where the gage is portable, and weight is a factor. These "A" size indicators are claimed to be sensitive and accurate, and are designated as A¼Q, A3Q, and A6Q-2. Model A¼Q is graduated 0.0001 in., Model A3Q is graduated 0.0005 in., and Model A6Q-2, 0.001 in. They are furnished with the American Gage Design Committee bracket back, or with post or flat type; special backs are also available. The indicator dials can be rotated to set the zero.

Pressure Lubrication Pump

The McIntyre Co., 15 Riverdale Ave., Newton 58, Mass.

The Series 1200 direct-drive gear pump is claimed to operate with a volumetric efficiency of 95 percent. Three standard models displace from 0.08 to 1.5 gal. per

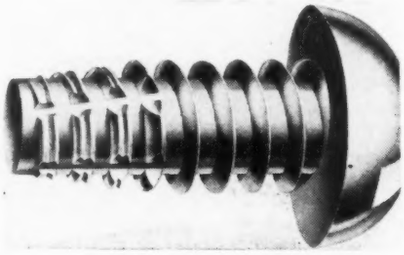


min. at speeds ranging from 1,140 to 3,450 r.p.m. against pressures to 150 lb. per sq. in. Standard models are designed for direct motor application, but can be furnished for flange mounting, belt, spline and other drives. Power requirements range from 1/100 to 1/6 h.p. The pump body is constructed of aluminum, with nitrided nitralloy spur gears and shafts. The unit weighs 8 ounces.

Self-Tapping Screw

Parker-Kalon Corp., 200 Varick St., New York 14, N. Y.

Five cutting flutes distribute cutting pressure and prevent localized pressure and cracking. The coarse threads offer resistance to stripping out and are claimed to eliminate binding by serving as a reservoir

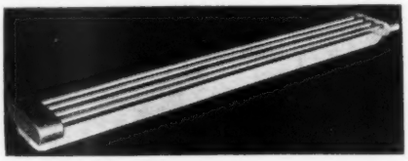


for the displaced material. P-K Type "F-Z" self-tapping screws are not available from stock but can be made up, with slotted or Phillips recessed heads.

Fluorescent Lighting Fixture

Colonial Lighting Co., Inc., 2901 Tonnele Ave., North Bergen, N. J.

Available for ceiling mounting or stem suspension, the fixture is 8 ft. long and 12½ in. wide and is available with two or four lamps. All internal parts are interconnected and lead wires brought to outlet for splicing to building service. Transformers are

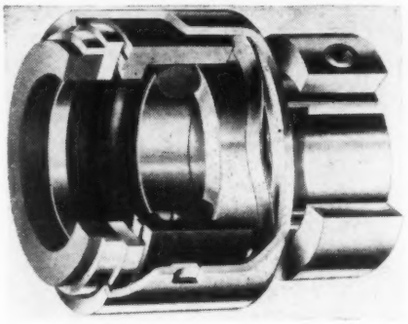


rated at 900 volts on the secondary side and operate from regular 110 volt a.c. line. 3,500 deg. white lamps furnished as standard. Daylight and soft white also available. Made of 20 gage steel with baked enamel finish. Selection of colors for end boxes. Channel is white. Underwriters approved. Square ends available as optional equipment for end-to-end installations. Transformers and internal wiring completely inclosed.

Mechanical Seal

Sealol Corp., 45 Willard Ave., Providence 5, R. I.

The "Sealol CB" is packaged as a complete seal, without loose parts. No skill or special tools are required to install the seal. It slides easily into position on the shaft and is locked in place with two setscrews. The

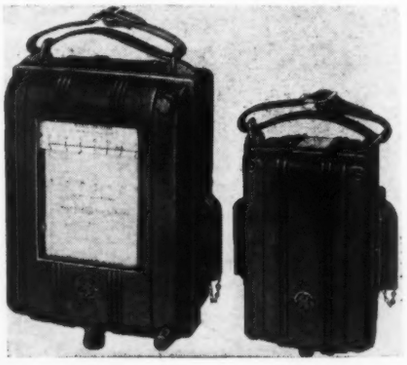


only relative movement is at lapped faces and reasonable shaft run-out does not affect the performance of the seal. Available in non-corrosive construction for shaft sizes 1/2 to 1 in., other sizes to order.

Inkless Temperature Recorder

General Electric Co., Schenectady 5, N. Y.

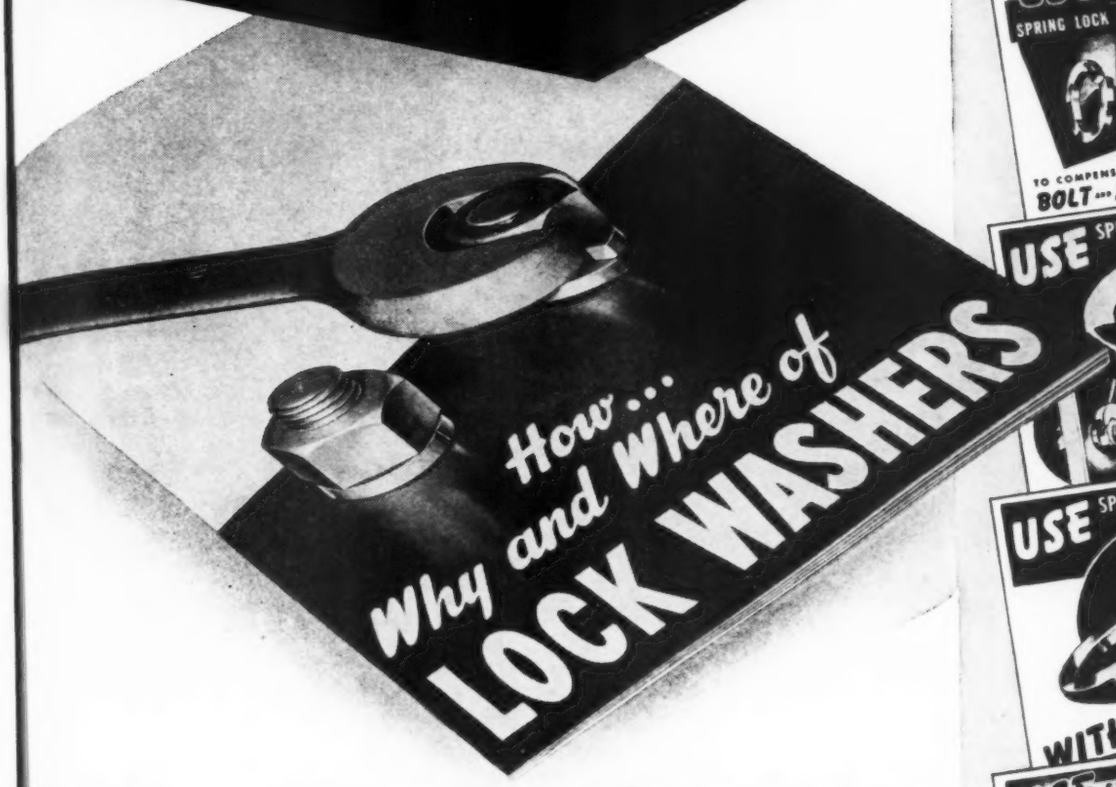
Designated as the Type CF-2, this temperature recorder consists of a portable recording instrument and an external power supply unit. The range of the fixed scale and chart scale on the recorder is 20 to 140 deg. C. With a chart length of 65 ft., the driv



ing motor can be adjusted to provide record length of from eight days to two years on a single chart. Weight of the recorder is 11 lb. Dimensions are 7 1/4 x 5 x 4 1/16 in.

IF YOU BUY OR SPECIFY LOCK WASHERS

GET THIS BOOK!



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DIAMOND G PRODUCTS

WASHERS • • FLAT WASHERS • • STAMPINGS • • SPRINGS • • HOSE CLAMPS • • SNAP AND RETAINER RINGS

The external power unit contains the constant voltage d.c. source, a part of the bridge circuit, and a lead-resistance compensating device. The weight of the power unit is 5 lb. Dimensions are 9 3/4 x 7 3/8 x 6 inches.

Inch Converter

American Hydromath Co., New York N. Y.

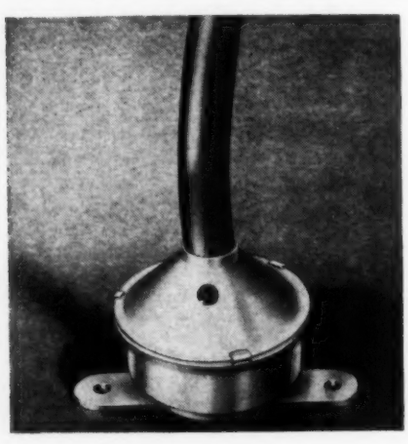
Known as the Calculaide, this unit is 5 3/4 in. long. Decimal equivalents are graduated in 0.001 in. and metric equivalents are graduated in 0.1 mm. Range is from 0 to 100 mm. All graduations are reproduced on facing surfaces and protected with a thin plastic lamination. U. S. standard gage sizes

from No. 3 through No. 30 are provided. Drill numbers from No. 1 through No. 60 are also shown. The unit is made from non-warping and non-inflammable plastic. Directions for use are printed on the back.

Hermetically Sealed Thermostat

The Spencer Thermostat Co., Attleboro, Mass.

An hermetically sealed snap-action thermostat for temperature regulation or high-limit alarms in refrigeration or other cooling or heating applications. Actuated by a snap-acting disk mounted in thermal contact with the sealed housing, they operate in any position and are claimed to be



unaffected by vibration. Supplied, ready to install, with a heavy-duty, all rubber, two-conductor cord 30 in. long. Minimum temperature setting is minus 10 deg. F., maximum standard temperature setting 120 deg. F. Minimum cooling temperature differential, with contacts closing on temperature rise, is 8 dg. F.; minimum heating temperature differential, with contacts opening on temperature rise, is 10 deg. F. Higher settings and wider differentials can be specified. They are available in the following electrical ratings for a.c. or d.c. application: 115-230 volts a.c., 10 amp., 1/2 h.p.; 125 volts d.c., 1 ampere.

Silicone Resin

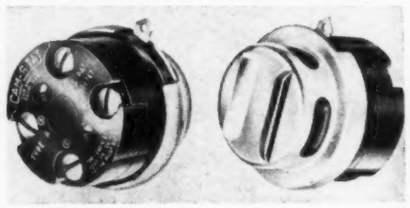
Dow Corning Corp., P. O. Box 592, Midland, Mich.

Known as DC-804, this silicone resin is designed for use in formulating heat resistant paints. It is similar to DC-803 except that it forms a considerably tougher film and requires less baking to produce a harder and more mar-resistant surface. This resin is reportedly resistant to temperatures of 500 deg. F. and upward. It has a high gloss and does not become chalky or yellow with age.

Thermostat

Cam-Stat, Inc., 2037 South La Cienega, Los Angeles, Calif.

A compact unit for general application at 120-240 volts a.c. is designed to meet the requirements of Underwriters' Laboratories. Measuring $1\frac{9}{16}$ in. in diameter and

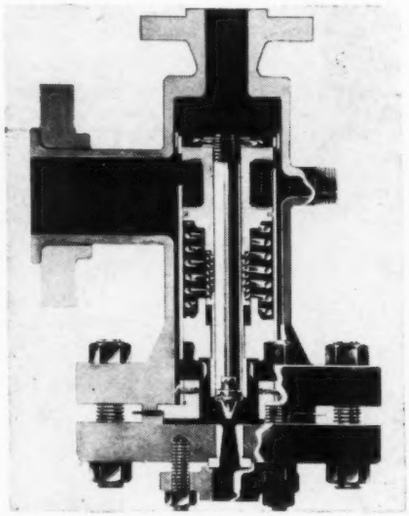


$1\frac{7}{32}$ in. in depth, this Type A Cam-Stat has a high current carrying capacity (1,500 volt-amps) without the necessity of a condenser; low differentials; a selection of temperature ranges from −50 to +350 deg. F.; resistance to vibration; and switching arrangements of single pole-single throw, break or make on temperature rise, single pole-double throw, and independent circuit double throw.

Recirculating Valve

Hammel-Dahl Co., 243 Richmond St., Providence 3, R. I.

Designed to eliminate centrifugal pump failures resulting from insufficient flow of fluid through the pump, this unit can be installed in existing pump piping by removing any elbow in the discharge piping upstream of all checks and stops. With little or no flow through the pump, the

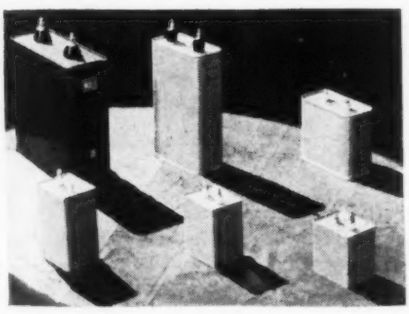


by-pass is wide open, recirculating enough fluid to prevent overheating. If the discharge rate increases, the plug in the valve approaches its seat, decreasing the quantity of fluid recirculated. When the flow through the discharge line is great enough to prevent overheating of the pump, the by-pass valve closes, allowing oil to pass through the discharge line. On decreasing flows, this cycle is reversed.

Capacitors

General Electric Co., Schenectady 5, N. Y.

Small and lightweight, d.c. Pyranol capacitors. Available in a range of ratings, with ambient temperature operating limits at rated voltage ranging from 0 to 50 deg. C. At 25 deg. C. the capacitance tolerances are ±10 percent.



Multiple Contact Connector

The Winchester Co., 6 East 46th St., New York 17, N. Y.

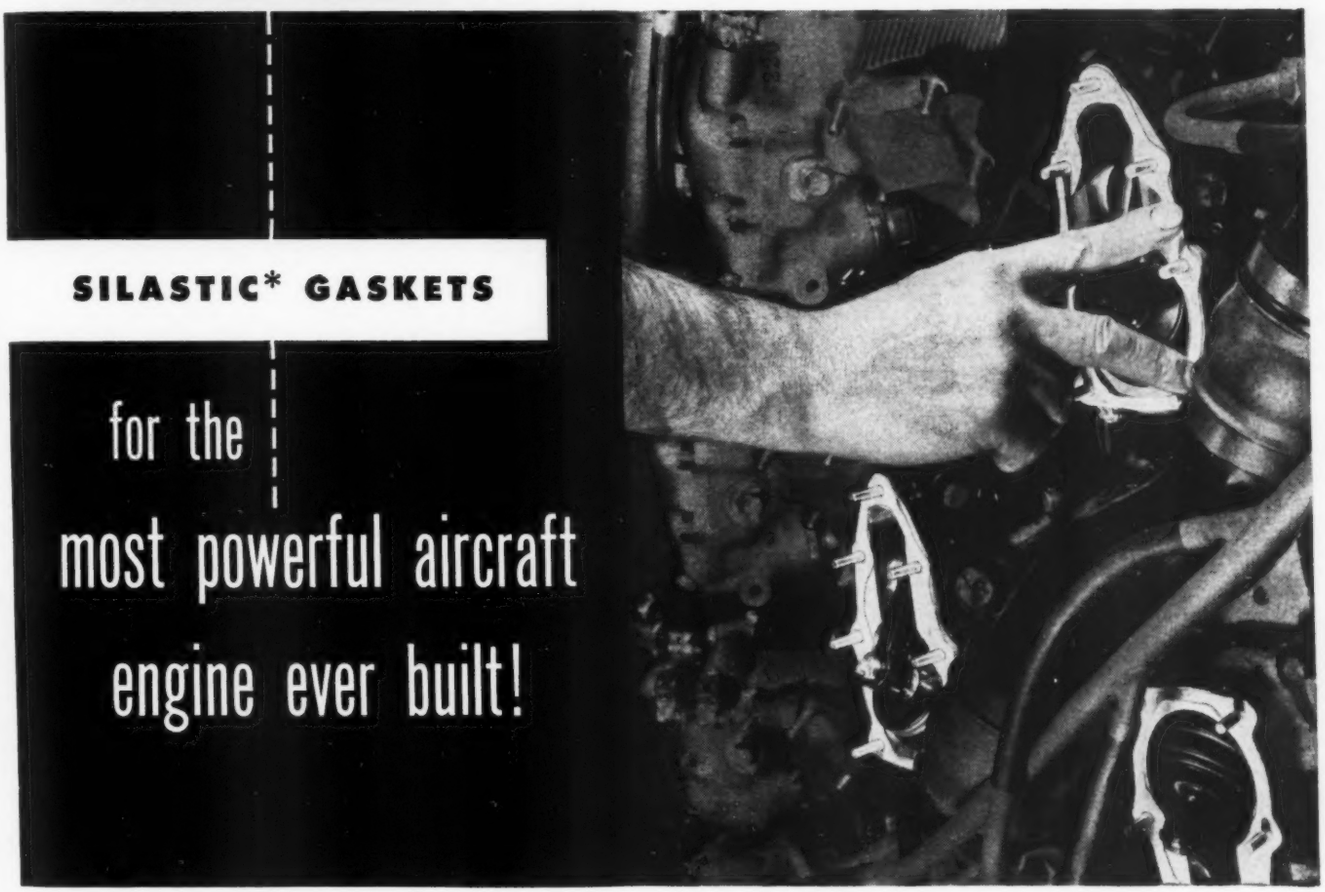
Molded of Melamine plastic, the one-piece inserts reduce the danger of flashover facilitated by moisture and dust accumulations. This connector can be supplied with a self-contained locking device for applications with very close space limitations. No external clamping is necessary. Multiple telescoping barriers isolate contacts and increase surface creepage and air gap between adjacent contacts. The connector

DOW CORNING

SILICONES

SILASTIC
FLUIDS
VARNISHES
RESINS
GREASES

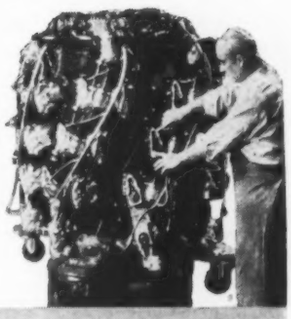
withstand heat
resist oxidation
exclude moisture



SILASTIC* GASKETS

for the most powerful aircraft engine ever built!

chosen best among all gasket materials tested for service at 450°F.



Silastic gaskets fabricated from Dow Corning silicone rubber by the Connecticut Hard Rubber Co. seal 56 rocker boxes of the 28-cylinder Pratt & Whitney Wasp Major.

"NOTHING BUT THE BEST!" That's the policy followed by Pratt & Whitney in selecting materials for the powerful new 28-cylinder, 3650 h.p. Wasp Major.

That's why Silastic was chosen for these rocker box gaskets. Factors in the choice were Silastic's resiliency at the 450°F. operating temperature, resistance to the hot oil, and convenience in handling.

Silastic will fly with the Wasp Major in such giant new airliners as the Boeing Stratocruiser, Douglas Globemaster, Martin Mars, and Republic Rainbow.

If you need a rubber-like material that's resilient up to 500°F. and flexible down to −70°F., call for "Silastic Facts" No. 1A—and *TRY SILASTIC!*

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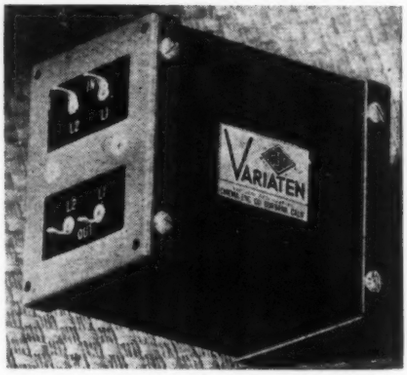
can be used at high potentials. Minimum air gap of $\frac{1}{8}$ in. is maintained between all contacts. Contacts are designed for use with a maximum wire size of #16 AWG. Available in two sizes; 18 contacts (QRE 18) and 12 contacts (QRE12), this self separating connector can also be supplied with straight type contacts (RE18 and RE12).

Orthocoustic Equalizers

Cinema Engineering Co., 1510 W. Verdugo Ave., *Burbank, Calif.*

Available for 500- and 600-ohm circuits, these equalizers deliver a fixed orthocoustic curve, equaliing for high frequency losses. Resistors, capacitors and inductances are individually bridged and adjusted. Inser



tion loss is approximately 16 db. They are fitted with two input and two output terminals, and shielded against pickup of extraneous inductance. Designed type 4137, equalizes measure 2 3/4 x 3 1/4 x 2 1/2 inches.

X-Ray Photometer

General Electric Co., Schenectady, N. Y.

A unit that indicates and records the concentration of one chemical element in the presence of others in solids, liquids or gases by measuring the change in absorption of X-rays between a sample and a standard. The X-ray photometer is housed in a standard control cabinet, 72 x 28 x 20 in. and incorporates a standard G. E. industrial generator. The X-ray transformer and tube are oil-immersed. The tube has a beryllium window and a tungsten target, and is water-cooled. re

Guess who didn't know an Adlake Relay was on the job!

AN Adlake Mercury Relay can always be depended on, whether it's in burglar alarms or any of hundreds of other uses.

Whatever your relay needs may be, only Adlake Plunger-type Mercury Relays offer you all these *plus* advantages:

Hermetically sealed; dust, dirt, moisture or oxidation cannot interfere with operation . . . mercury-to-mercury contact; chatterless, silent, impervious to burning, pitting or sticking . . . absolutely safe . . . no maintenance required.

Write today for free, illustrated Adlake Relay folder! No obligation, naturally.

Is there a job here YOU want done?

Adlake Plunger-type Mercury Relays are *proved best* in these and other applications:

Radio transmission • Standard telephone circuits • Precision control instruments • Animated displays • Railroad and traffic controls • Burglar alarms • Heating and ventilating controls • Refrigeration controls • X-ray control • Dry cleaning equipment • Remote and automatic controls • Production line time controls • Photoelectric apparatus • Motor reversing switches • Sign flashers • Electric time controls • Navigation buoy flasher light controls • Surgical lighting controls • Cable electrolysis prevention • Signals and indicators • Electric call systems • Across-the-line motor start switches • Power circuits • Air-conditioning controls • Mill and factory service • Voltage regulators.

Adlake TRADE MARK

THE ADAMS & WESTLAKE COMPANY

ESTABLISHED IN 1857 **ELKHART, INDIANA** NEW YORK · CHICAGO

Manufacturers of Adlake Hermetically Sealed Mercury Relays for Timing, Load and Control Circuits

No Crowding at the Corners

Air or air-borne light solids passed through SPIRATUBE* find a smooth channel that takes the turns without seriously reducing free area.

It's spiral-stitching (a SPIRATUBE exclusive) that makes the difference. No exposed wires to collect solids. No accordion-like crimping at the turns, as with ring-reinforced ducts.

LIGHT—RETRACTABLE
QUICK-CONNECTING—SAFE—RUGGED

For *efficient* conveying, specify SPIRATUBE—non-collapsible under pressure or vacuum. For *convenience*, specify SPIRATUBE—light-weight, quick-connecting, self-extending, retractable to 1/8 extended length for easy stowing. For *safety*, specify SPIRATUBE—fire-resistant processed, no exposed metal. For *long life*, specify SPIRATUBE—strong-fibre duck, thermoplastic-coated.

SPIRATUBE was proved in active duty with U. S. Navy. 3"-16" diam.; lengths up to 25'.

FREE FOLDER Address The Warner Brothers Company, SPIRATUBE DIVISION, Bridgeport 1, Conn. Branches: New York, Chicago, San Francisco. *Mail coupon for detailed information*

Now non-collapsible tubing can be tied in knots without blocking passage of air or solids.

Portable or Semi-Permanent Installation

***Ventilation*—aircraft, automotive, mines, underground construction, shipholds, tanks and tank cars, etc.**

Pre-cooling, Drying, Fumigation, Cleaning.

***Product or by-product conveying*—chemicals, cotton, dust, fertilizer, food (cereals, flour, sugar), fumes, furnace soot, gases, grinding wastes, insulation, paper trim, sawdust, lint, etc.**

*Patent Pending

SPRINGS TO WORK . . . STAYS EXTENDED . . . TAKES SHARP TURNS . . . CINCH TO STOW . . . FOR AIR, GASES, POWDERED, GRANULAR OR OTHER LIGHT SOLIDS

The Warner Brothers Company, SPIRATUBE DIVISION
337 Lafayette Street, Bridgeport 1, Conn.
Gentlemen: Please send free folder on SPIRATUBE.

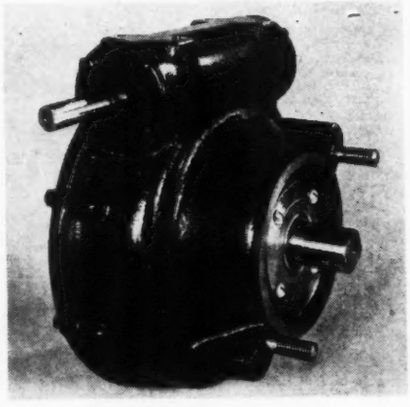
Name.....
Company.....
Address.....

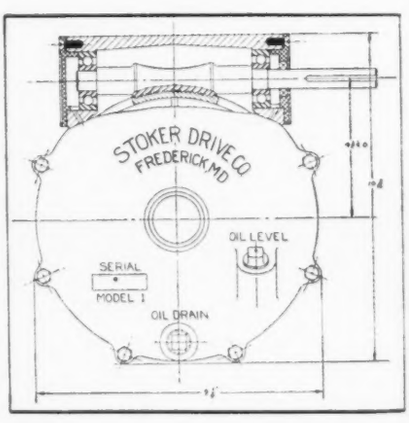
quiring four pints of water per minute at 20 lb. per sq. in. for cooling. The equipment meets A. S. A. Class A Standards 254.1-1945 Safety Code for industrial use of X-rays.

Stoker Drive

Stoker Drive Co., Frederick, Md.

This unit, using cone-drive gearing, is available in three sizes. The smallest is for stokers from 15 to 50 lb. per hr. (driven by 1/8 to 1/4 hp. motors). The next largest size is for units handling from 75 to 250 lb. per hr. (1/4 to 1 hp. motors). The largest size is for units handling from 250 to 1,200 lb. of coal per hr. (motors of 1 to 5 hp.). The drive consists of a





single gear set speed reducer that attaches to the stoker feed mechanism by the standard mounting method. The cone-drive gear set is in a ratio of 200:1. With a 4:1 V-belt drive this steps the motor speed of 1,750 r.p.m. to 2.2 r.p.m. for the gear shaft and stoker feed screw.

Automatic Overload Release Clutch

The Carlyle Johnson Machine Co., Manchester, Conn.

An adaptation of the Maxitorq floating disk clutch, this unit can be assembled, adjusted or taken apart without tools. The overload release clutches can be used on a continuous shaft or as a cut-off coupling

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Because the bottom is so much heavier than the sidewall, this aluminum alloy geophone case was originally made as a two-piece assembly. Now Scovill forges the inside and outside to finished dimensions, facing the bottom to a square corner, and countersinking and tapping the open end. Three holes are drilled in the bottom, the large center hole being also tapped . . . Typical of Scovill's observance of close tolerances in forging, this instrument part is a more satisfactory, less expensive job than the assembly it replaced.

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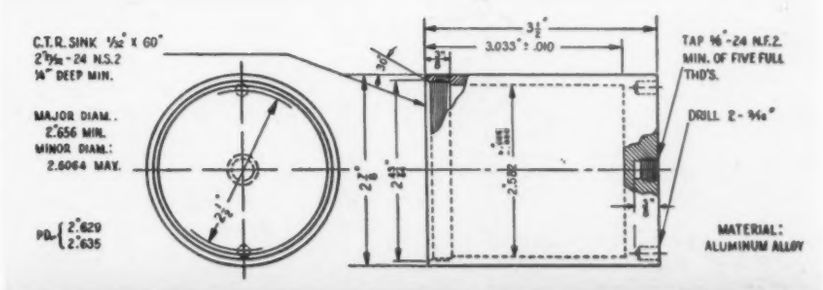

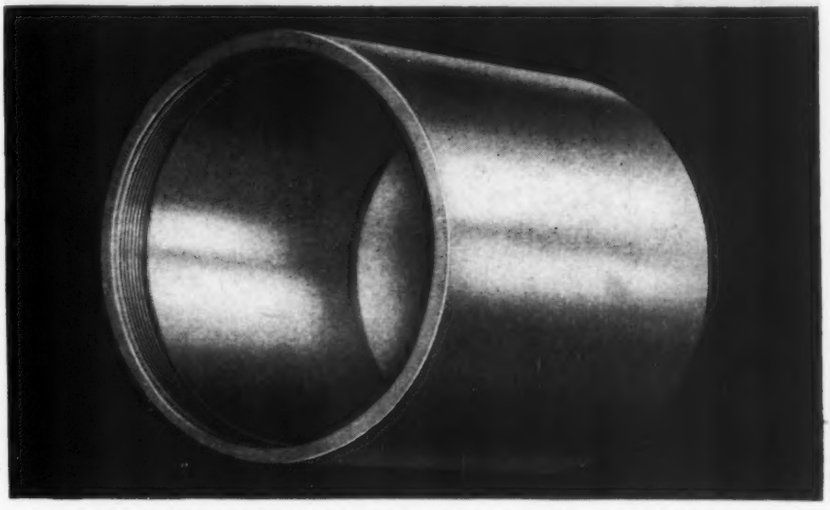

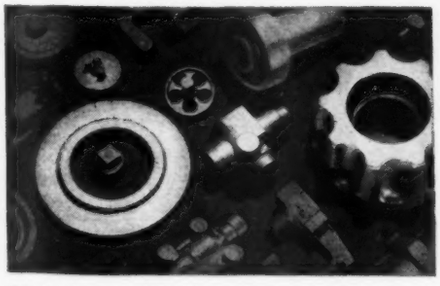

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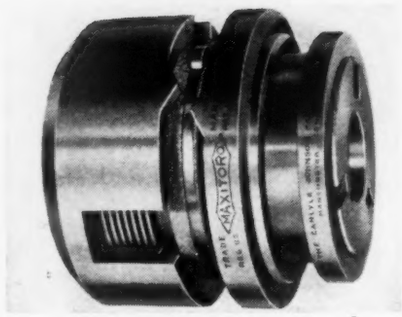


type for connecting two shatts. The axial sleeve pressure varies with the torque to be transmitted up to the maximum of each clutch size. Maxitorq overload release clutches are available in 6 standard sizes: ¼, ½, 1, 1¾, 3 and 5 horsepower.

Steam Cleaning Detergent

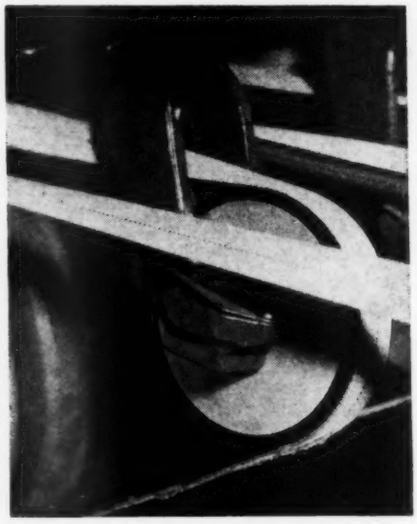
Oakite Products, Inc., 57 Thames St., New York 6, N. Y.

A high-speed detergent, Oakite Composition No. 92, for cleaning machinery and equipment parts, preparing equipment surfaces for repainting or refinishing, or paint stripping. This material is claimed to give thorough and fast steam-cleaning action at low concentrations. Further claims include: Prevention of scale clogs in steam coils; dissolution in hot water; free-rinsing action on all surfaces; safe handling without offensive fumes or toxic vapors.

Tape Tension Pulley

SKF Industries, Inc., Philadelphia, Pa.

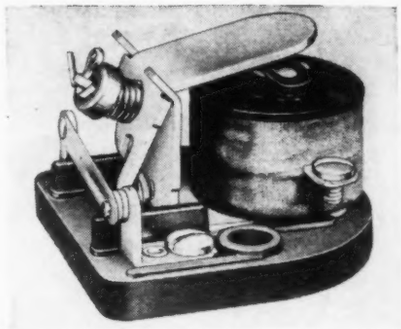
A unit that can be mounted on all cotton spinning frames. The pulley, 4 in. in diameter, consists of a plastic shell with aluminum shields mounted on a deep groove ball bearing having a stationary shaft. Plastic blocks of the same external dimensions as the wood bearings support the pulley shaft and fit present spinning frame brackets. Aluminum shields protect the ball bearing from lint and fly. Lubrication is required every three years.



Motor-Starting Relay

Potter & Brunmfield Sales Co., Dep't. 231, 549 West Washington Blvd., Chicago 6, Ill.

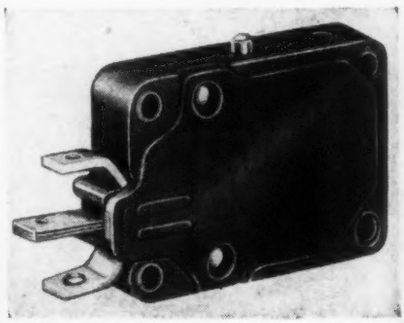
The Model MS2A relay is voltage-actuated and operates on the back e.m.f. of the starting winding. When the motor has attained speed this unit immediately disconnects the starting coil from the line. The MS2A relay operates over a range of line voltage variations and is claimed to be reliable on normally low lines. Its wide differential gives a high pull-in voltage and low drop-out. The unit can be mounted on the motor housing or located at any distance, thus permitting operation of the motor in a combustible atmosphere.



Miniature Switch

Acro Electric Co., 1310 Superior Ave., Cleveland 14, Ohio

The Model "M" rolling-spring snap-action electric switch has a molded case with a recessed cover inserted clear of the four mounting holes, which are $\frac{3}{32}$ in. in diameter. Solder terminals are used with



0.082 in. terminal holes. This switch is made for single and multiple assemblies. It is made with single pole, single or double throw contacts and is rated at 10 amp. 125 volts a.c.

Rust Preventing Agent

Pennsylvania Salt Mfg. Co., Phila., Pa.

For use in water on ferrous metals before painting, enameling or between machine operations. The product, packaged in 25, 100 and 300 lb. fiber drums, is Pennsalt RI-50, an inorganic salt mixture. It requires no rinsing before painting.